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January-February 1951

*Journal of*

# MILK and FOOD TECHNOLOGY

*Official Publication*

International Association of Milk and Food Sanitarians, Inc.

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*Journal of*

# MILK and FOOD TECHNOLOGY

**INCLUDING MILK AND FOOD SANITATION**

*Official Publication*

**International Association of Milk and Food Sanitarians, Inc.**

VOL. 14 **JANUARY-FEBRUARY 1951** NO. 1

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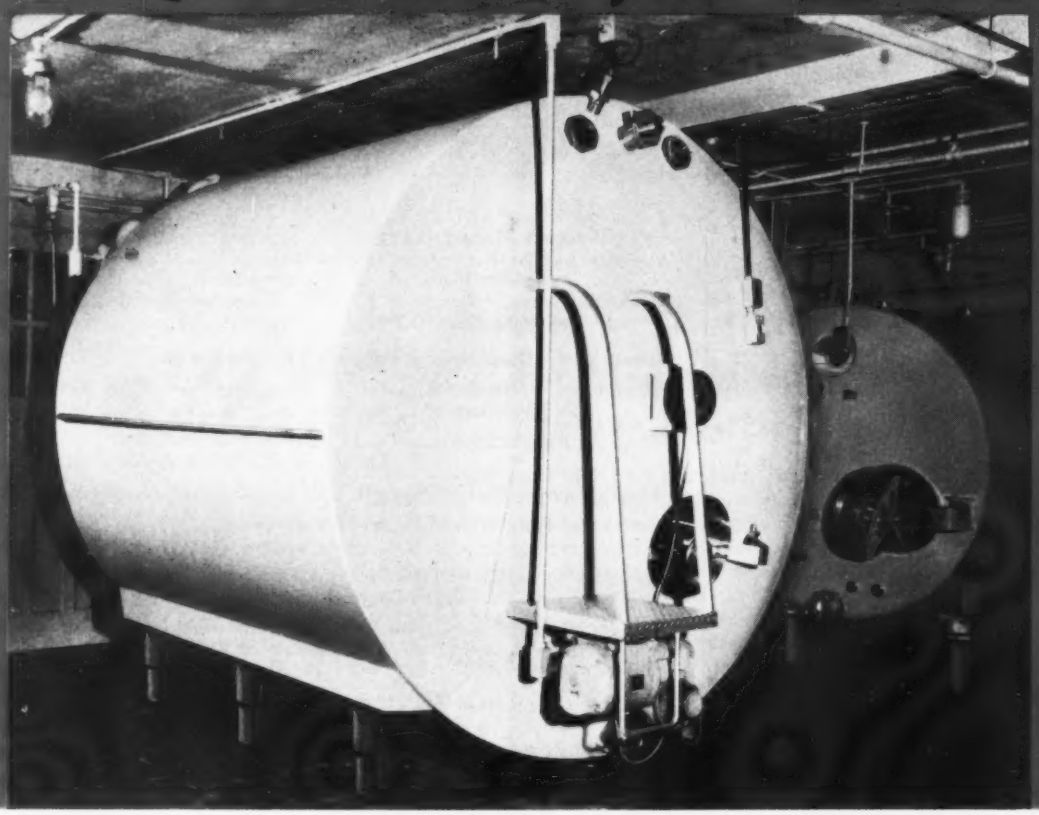

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# EDITORIAL NOTES

## PRESIDENT'S MESSAGE

*Greetings, Fellow Members:*

I AM very pleased to present to you, the elected officers of the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, whose pictures are presented in the group photo accompanying this message. The Executive Board, consisting of the officers, represents a broad composite in milk and food sanitation experience and work. As for myself, my training and experience has been in the fluid milk business in Ohio, and subsequently in the academic field in teaching, research, and extension at the University of Wisconsin.

George West, our very able and conscientious secretary, (you should see the cross-fire of correspondence on Association matters that crosses his desk) is Director of Environmental Sanitation in the City of Rochester, New York, and brings, with his knowledge of community public health control, an effective and sincere administration of the details in the operation of our organization.

H. L. Thomasson, Milk Sanitation Consultant of the Indiana State Board of Health, is President Elect of this organization. Through his years of experience in state and community work, our Association can look forward to effective counsel and leadership.

Recently elected members to the official family are Harold Barnum and John Faulkner. Harold Barnum, First Vice-President, is Chief of the Milk Section, of the Bureau of Health and Hospitals in the City of Denver. He has had many years of experience in milk sanitation work in Michigan, and more recently in Denver. John Faulkner, Second Vice-President, is Assistant Chief, Milk and Food Branch, of the U. S. Public Health Service in Washington. Through his work and experience, he is able to bring counsel to the Association from the interstate and national viewpoint.

The Executive Board, therefore, is composed of individuals who, through their associations and experience, can represent to good advantage the various fields of endeavor of the milk and food sanitarians' profession.

The Executive Board has given many hours of patient study to the matter of financing the activities of the Association and in publishing its Journal. Every effort has been made in recent years to maintain an adequate income for the Association and the Journal in the face of constantly increasing costs of materials, printing, and services. The costs of performing the activities of the Association have definitely outrun the economies that have been possible; this experience, of course, is no more new for the Association than for its members. In order to eliminate a status of deficit financing, a moderate increase in membership dues to cover the Association costs, and for the Journal, has been determined.

Reading from left to right—M. R. Fisher, *Retiring President;* H. L. Thomasson, *President Elect;* G. A. West, *Secretary-Treasurer;* H. J. Barnum, *Second Vice-President;* J. D. Faulkner, *First Vice-President;* K. G. Weckel, *President.*

The activities of the Association involve a considerable amount of detail work, through its several very active Committees, and its several thousand members. In order that a more effective and prompt supervision of its affairs is possible, the Executive Board appointed Mr. George A. West, Association Secretary, to serve as Publisher of the Journal, to assume liaison responsibility between the offices of the Association Secretary, the Editor, Dr. J. H. Shrader, and the Business Manager, William Palmer, of the Journal, and the printer. It is expected that the activities of the Association, including the publishing of the Journal for its members, will be more effectively expedited by this arrangement.

The Executive Board has given much thought to the matter of increasing income through means other than membership dues, to enable publication of its Journal on a monthly rather than a bi-monthly basis, and to enable addition of subject material of interest to a greater number of the members. There is strong desire among members for service in this direction. It is the expectation that this objective can be attained by diligent effort. One of the principal reasons for the existence of an organization is to enable group review of, and development of activities in the field of sanitation. The INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS has the good fortune to have Committees whose members get things done, and who do contribute to the progress in the profession and of the

sanitarian. The appointment to membership in one of the Committees is one that involves sharpening mental viewpoints, and oftentimes detail work; it is an award of commendation; a recognition of professional status. I believe you will be interested in the Committees appointed for the coming year, and their objectives.

Every sanitarian in the Association must be familiar with the work of the Committee on Sanitary Procedure. This Committee has represented the Association in its joint participation with the Sanitary Standards Sub-Committee of the Dairy Industry Committee, and with the U. S. Public Health Service, in the development of Sanitary Standards for Dairy Equipment. Mr. C. A. Abele of Evanston is Chairman of the Sanitary Procedure Committee. Since 1944 this Committee, jointly with the others, has developed standards for twelve different lines of equipment, and currently is engaged in the study of some fifteen others through its designated task committees. One of the very gratifying things of the work of the Committee is the rapid acceptance of its work in the dairy industry, and of the beneficial influence it is having. The Association's 3A Symbol is a watermark of distinction.

The Committee on Ordinances and Regulations, under the direction of Mr. C. J. Babcock has, through its reviews, caused the focusing of attention on the part of sanitarians to those factors basically essential to sanitation.

The Committee on Communicable Diseases Affecting Man, headed by Dr. I. A. Merchant, Iowa, is planning on analyzing a number of recent milk-borne epidemics and to characterize therefrom a milk-borne epidemic in terms of modern procedures of production and processing.

The Committee on Applied Laboratory Methods, the Chairman of which is Dr. Luther Black, Cincinnati, has been very active in the study of the measure of quaternary compounds, and their rate of effectiveness, and in bacteriologic technique. Consideration will be given by this Committee to thermal resistance of microorganisms to heat and to review time and temperature equivalents for HTST pasteurization. Study on the testing of antibiotics, and on comparative phosphatase tests will be undertaken.

Dr. R. G. Ross, Oklahoma, as Chairman of the Committee on Dairy Farm Methods, is heading up reviews of matters such as practicability of sanitizing farm pipe lines in place, paper towels for udders, hosing down of cows before milking, tests for colostrum milk, and farm truck refrigeration.

The Committee on Frozen Foods, under the direction of Dr. Marvin Speck, North Carolina, is planning evaluation of the various standards for ice cream and other frozen desserts, and frozen foods, and to review them for the Association.

The Committee on Food-Handling Equipment, headed by Mr. Clarence Weber, New York, has worked closely with the Joint Committee of the National Sanitation Foundation in the proposed Standards for Dishwashing Machines, now under review. This Committee has been called upon to represent our Association in meetings with several branches of the food industries in which standards for food handling equipment are under consideration.

The Association has not had the help and guidance of an active Membership Committee for a period of years. With the increase in activity between affiliate organizations and the Association, and the need for guidance and counsel in matters pertaining to membership which must be augmented if the organizations are to serve themselves and the profession, the Executive Board has appointed Mr. Ed Graber of Ohio as Chairman of the Committee on Membership. Through these very active groups, and through interim appointments, the Executive Board believes that the affairs of the Association will be properly administered, and the organization become stronger through its accomplishments.

The Executive Board has chosen Glenwood Springs, Colorado, as the place for the meeting to be held September 26–29, 1951. Colorado was chosen for several reasons: to enable members in Western States to participate in the meetings and Association affairs, enable others in this country to observe the developments in sanitation practices and thought in the western area, and to enable for hard working sanitarians a real place to temper work with relaxation. Every member of the Association is urged to plan, and save, for this meeting.

The Executive Board, and Officers urge you to participate actively in the activities of the Association and its affiliate organizations, to contribute to the cultural and professional advancement of the sanitarians, and to develop a feeling of proprietorship in the Association.

Sincerely,

K. G. WECKEL

*President*

INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS

## THE AFFILIATE REPRESENTATIVES BREAKFAST

DURING the Annual Meetings at Atlantic City, representatives of the twelve dairy and food sanitarians' associations affiliated with the International Association of Milk and Food Sanitarians, met for a breakfast, to become better acquainted, and to review mutual problems in the respective organizations. The officers of the parent organization "presided" at the breakfast. Twenty-three men, who posed for the group photo below, attended the breakfast meeting. It is planned to continue these group meetings of affiliate representatives at future annual meetings of the Association, as it provides excellent opportunity for discussing affiliate matters.

C. H. Holcombe, G. A. Vacha, H. E. Erickson, Dr. J. C. Olson, Jr.—Minnesota Milk Sanitarians Association.
P. E. Riley, F. M. Keller—Associated Illinois Milk Sanitarians.
K. G. Weckel, Evert Wallenfeldt—Wisconsin Milk Sanitarians Association.
Milton Held, H. E. Peebles, J. H. Burckett, and R. A. Dunn—Iowa State Milk Sanitarians Association.
B. J. Northrup—Florida Association of Milk and Food Sanitarians.
Ivan Nortwick—Kansas Association of Milk Sanitarians.
Dr. R. G. Ross—Oklahoma Association of Milk and Food Sanitarians.
Dr. R. R. Palmer, Dr. W. L. Mallman—Michigan Association of Sanitarians.
J. H. McCutcheon, Dr. M. R. Fisher, J. L. Rowland—Missouri Association of Milk and Food Sanitarians.
George West—New York Association of Milk Sanitarians.
Dr. K. G. Weckel, H. L. Thomasson, H. J. Barnum, John Faulkner, George A. West, and Dr. Milton Fisher—INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, INC.

## THE REPORT ON THE STUDY OF MILK LEGISLATION

IN 1946 the National Research Council received a grant under the Research and Marketing Act to study milk regulations in relation to milk quality.[1] Two major phases of research were included in the project: (1) a compilation and analysis of state and municipal statutes and regulations concerned with the production, handling, processing, transportation, and distribution of fluid milk products; (2) the effect of such statutes and regulations, as measured by their administration and enforcement, as well as by actual experimental procedures, on the quality of milk.

The first phase of this project has been completed and published.[2] The second phase is now under investigation.

[1] This Journal, *12*, 303 (1949).
[2] Bull. Natl. Res. Council, No. 121, July 1950.

An excellent summary of the legislative and regulatory enactments is presented in Dr. Dahlberg's paper which we publish in condensed form on page 31, this issue. An examination of the report shows that the "requirements" are all over the map and many times, contradictory. Why the multiplicity of grades? Why the great diversity in bacteria standards, from no requirement right on up the line? Why the specificity for relative location of milk house and barn and yet no bacteria standards? We recognize that economic and geographical considerations must affect the setting of requirements, as for example, the cooling of milk. Only 5 cities out of 84 reporting, and none of the 48 states, mentioned mechanical cooling; and only 28 cities and 8

states mentioned water-tank cooling. Yet note the attention paid to location of milk house:

| | Integral part of stable | Feet away specified if not integral part |
|---|---|---|
| States reporting...48 | 41 | 4 |
| Cities reporting...84 | 70 | 14 |

The emphasis on their relative importance is upside down.

We are greatly impressed with one outstanding fact, anyhow, that 100 percent of both states and cities reporting provide standards of some kind for pasteurization of milk.

Now what does all this scatter of data mean? Why do regulations all over the country differ so markedly in what they require? Each author doubtless wrote down what he *thought* was necessary. Were they all correct? If not, which ones were? In all this confusion, the industry is befuzzled as to what to do, the inspectors are embarrassed (to say the least)—and the public pays.

The Research Council now takes up the second phase, namely a study of milk quality as actually produced. "The proof of the pudding is in the eating." Actual facts are being assembled under carefully controlled conditions. For example, bacteria determinations are made by the same laboratorians, using media from the same batch. These findings will give an excellent presentation of the relative quality of milk as produced and distributed.

The data therefrom will have to be interpreted with caution. Their relation to the regulatory requirements may not constitute a measure of the soundness of the enactments. There is another factor to be considered, a variable that is very difficult to measure, namely, the human element. A milk supply under the supervision of an intricate, detailed regulatory and enforcement structure may run relatively poor in quality. On the other hand, an efficient and competent milk sanitarian can produce a high quality of milk with very little regulatory coercion. We know of one who has done a great job under no regulations. Also, we once knew a distributor who had the dirtiest premises but produced the lowest count milk in the city (he knew milk but not environmental sanitation—incidentally, he went, under pressure, out of business!).

A study such as the instant one is highly commendatory. Facts are being brought out. These are what is wanted. Opinions must come later when interpretation is in order. The investigation must not lag. A tightening of our conditions of living is portended by the trend of international events. Too much good data have already been secured to allow anything short of a national catastrophe to stop this work. The project is in good hands and is proceeding in excellent fashion. We hope that everyone who can help in any way will assist this constructive study.

J. H. SHRADER.

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## 38th ANNUAL CONVENTION IAMFS GLENWOOD SPRINGS COLORADO SEPTEMBER 26-29, 1951

SANITARIANS in Colorado and neighboring states are planning big things to make your visit next September at the 1951 meeting one of the most memorable and enjoyable you have attended. We hope that you are planning your vacations now so that you can combine that vacation with attendance at this annual meeting.

Here you will find Western hospitality at its best. The site for the meeting is ideal. Glenwood Springs is located in the heart of the Rockies. It is surrounded by magnificent mountains and is easily accessible by motor, train, and air. The silvery Colorado River flows through the town. In addition to the Colorado, the Eagle, the Frying Pan, the Roaring Fork, and numerous mountain streams beckon the ardent trout fisherman. Within a block of the headquarters hotel, the Colorado, is the world's largest outdoor swimming pool, fed with millions of gallons daily of hot mineral water. Swimming is enjoyed here every day of the year. Nearby is historic Aspen, famed as a culture and skiing center, and for the world's largest ski chair lift. A trip on this lift, when the aspen trees are in their full glory, is a rare treat and a must for every tourist. Nearby beautiful Maroon Lake, Red Cliff Mansion, towering mountain peaks, and hundreds of other scenic attractions all make this area a tourist's paradise.

Glenwood Springs is located 170 miles west of Denver on U. S. 40. The drive from Denver is

over 11,991 ft. Loveland Pass, the highest transcontinental highway in the U. S. It is 425 miles east and south of Salt Lake City. U. S. 40 is a smooth, well paved highway abounding with scenic wonders. A vacation trip might well include Rocky Mountain National Park, Mesa Verde National Park, Colorado Springs, and any number of hundreds of other scenic attractions found only in the Rocky Mountains. September in the Rockies is the most beautiful time of the year.

Your Western friends are hard at work to make sure that you and your ladies are entertained with the kind of entertainment you want when you come West. This will be the best opportunity to combine business and pleasure the INTERNATIONAL ASSOCIATION has ever offered. Plan now to bring your family, your sport clothes, your swimming suits, and be prepared to enjoy and learn.

HAROLD J. BARNUM.

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## Report of the Committee on Sanitary Procedure

The Committee on Sanitary Procedure is in position to report progress on the projects which were outlined in the 1949 report.

"Sanitary Standards for Stainless Steel Automotive Transportation Tanks for Milk and Fluid Milk Products (3A)", "Sanitary Standards for Electric Motors and Motor Attachments (3A)" and "Sanitary Standards for Seamless and Welded Tin-Coated Can-Type Milk Strainers (3A)" acted upon just prior to the Columbus meeting, were published in the January–February number of the JOURNAL.

At a joint meeting with representatives of the Milk and Food Branch of the U.S.P.H.S., and the Sanitary Standards Subcommittee of the D.I.C. in Chicago, on June 5 and 6, "(3A) Sanitary Standards for Milk and Milk Products Filters Using Disposable Filter Media," and "(3A) Standard Method for Determining the Holding Time of High-Temperature Short-Time Pasteurizers by Means of the Salt Conductivity Test" were approved. These were published in the September–October number of the JOURNAL.

Sanitary standards are currently in process of being formulated for milking machines, for heat-exchangers—of the cabinet and surface type, of the plate type, and of the internal tube type, for can-washers, for batch pasteurizers, for factory-size clarifiers and separators, for milk-bottle fillers and cappers, for milk pails, and for ten-gallon shipping cans. It is not anticipated, however, that sanitary standards covering all of these items can be developed to the approval stage during the next twelve months.

At the time of the Columbus meeting the New York State Association of Milk Sanitarians had organized a committee to collaborate with the Committee on Sanitary Procedure. During the past year the affiliated associations of Illinois, Kansas, Missouri, Oklahoma, and Virginia have also named such committees. These committees were requested to make suggestions for provisions to be incorporated into the sanitary standards for milking machines, and the response has been extremely gratifying. It may be anticipated that the interest of, and suggestions from, these affiliate committees will be of significant assistance to the committee in its consideration of tentative standards. It is desirable that every affiliated state association of sanitarians organize such a committee.

The preparation of folders of all of the sanitary standards published to date has been given much study since the last meeting. Although the tangible result of the consideration given the matter is, for the moment, somewhat short of the ideal envisioned, a temporarily practical compendium of the standards, including planographed drawings of pipe and thermometer fittings (in a size which can readily be read), has been made available to those present who wish to avail themselves of the opportunity. The availability of copies of specific reprints, and of the set, has also been announced in the JOURNAL.

Application for registration of the 3-A symbol, for use on storage tanks, weigh-cans, and receiving tanks, has been made, although favorable action has been delayed because of a minor technicality. It is felt that the Committee will be able to announce, in an early issue of the JOURNAL, that the symbol has been registered.

C. A. ABELE, *Chairman*

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|---|---|
| H. E. BREMER, | M. V. HOWLETT, |
| PAUL CORASH, | H. L. THOMASSON, |
| C. B. DALZELL, | HAROLD WAINESS, |
| A. H. FARRELL, | H. I. WEAVERS, |
| M. R. FISHER, | C. W. WEBER. |
| O. H. GHIGGOLE, | |

* Presented at the Thirty-seventh Annual Meeting of the International Association of Milk and Food Sanitarians, Inc., Atlantic City, N. J., Oct. 13–16, 1950.

## COMMITTEES OF THE INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, INC., FOR 1951

### Applied Laboratory Methods

Dr. L. A. Black, *Chairman*, U.S.P.H.S., Eighth and Walnut Sts., Cincinnati, O.; Dr. F. W. Barber, National Dairy Research Labs., Oakdale, L. I., N. Y.; Dr. P. R. Elliker, Oregon State College, Corvallis, Ore.; Dr. C. K. Johns, Central Experimental Farm, Ottawa, Canada; W. K. Moseley, 3862 E. Washington St., Indianapolis, Ind.; J. N. Murphy, Jr., 2503 Spring Lane, Austin, Texas; Dr. J. C. Olson, Jr., University of Minnesota, University Farm, St. Paul, Minn.

### Communicable Diseases Affecting Man

Dr. I. A. Merchant, *Chairman*, Iowa State College, Ames, Ia.; Dr. R. G. Flood, San Francisco Medical Commission, San Francisco, Calif.; Dr. R. J. Helvig, Milk and Food Branch, U. S. Public Health Service, Washington, D. C.; Dr. Stanley Hendricks, Iowa Department of Health, Des Moines, Ia.; Dr. C. H. Mader, Board of Health, Kitchener, Ontario, Canada.

### Dairy Farm Methods

Dr. R. G. Ross, *Chairman*, 134 Jasper St., Tulsa, Okla.; Chester F. Bletch, 1756 K Street, N.W., Washington, D. C.; Dr. L. E. Bober, 2843 W. 19th St., Chicago 23, Ill.; J. E. Dolan, Colorado Dept. of Public Health, State Office Bldg., Denver 2, Colo.; J. C. Flake, 307 N. Michigan Ave., Chicago 1, Ill.; Milton E. Held, Iowa State Dept. of Health, Des Moines, Ia.; Dr. F. L. Schacht, New York State Dept. of Health, 18 Dove St., Albany 6, N. Y.

### Food-Handling Equipment

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### Frozen Food Sanitation

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*Oklahoma Association of Milk and Food Sanitarians*

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*Virginia Association of Milk Sanitarians*

C. B. Neblett, State Dept. of Health, Richmond, *Chairman;* Dr. C. C. Flora, Dairy Dept., Virginia Polytechnic Institute, Blacksburg; G. S. Kennedy, City Health Dept., City Hall, Roanoke.

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### Meeting of Sanitary Standards Subcommittee of the Dairy Industry Committee

Thirty-seven men, representative of the U. S. Public Health Service, International Association of Milk and Food Sanitarians, and the Sanitary Standards Subcommittee of the Dairy Industry Committee, met in Washington, D. C., on December 5 and 6 to continue work on the establishment of 3A Sanitary Standards for dairy equipment.

Included in the group representing the SSS-DIC are representatives of the American Butter Institute, American Dry Milk Institute, Dairy Industries Supply Association, Evaporated Milk Association, International Association of Ice Cream Manufacturers, Milk Industry Foundation, and the National Cheese Institute.

The dairy equipment manufacturers, acting through task committees, presented proposals on Can Washers, Internal Tubular Heat Exchangers without Agitators for use with Milk and Milk Products, Plate Type Heat Exchangers for Milk and Milk Products, Flush Type Sanitary Plug Valves, Milking Machines, Washing Pipe Lines in Place, Sanitary Fittings, and Threads in the Milk Zone. These 3A Standards, as proposed, were referred back to the task committee for further clarification.

# THE SANITIZING OF MILK CANS IN MECHANICAL CAN WASHERS[1]

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AND

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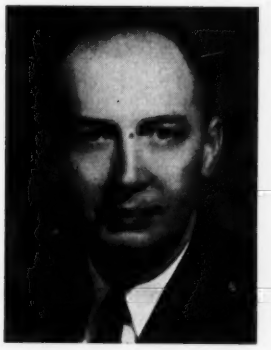

DR. S. L. TUCKEY graduated from the University of Illinois and took his Ph.D. degree in 1937. During World War II, he spent two years in the European theater and served with the Nutrition Section of the Sanitary Corps. Military honors included the Bronze Star Medal and the Croix de Guerre from the French government. He has published more than thirty articles with co-workers, dealing with various problems in dairy technology. He received the Borden Award in Dairy Manufacturing in 1939 from the American Dairy Science Association.

TO USE milk cans free from bacteria, moisture, corrosion, deposits of organic and inorganic material, as well as other defects responsible for milk contamination, is one of the objectives of those concerned with the production of high quality milk. The attainment of this objective has been delayed because no mechanical washers have been designed which satisfactorily solved the problems related to economical washing and sterilization of milk cans. Improvements in the design and construction of can washers in the past decade have increased their effectiveness in sanitizing cans and therefore warranted study.

The purpose of this investigation was to determine:

1. The bactericidal efficiency of the treatment which milk cans receive in commercial can washers.
2. The factors influencing the bactericidal efficiency of can washing operations.
3. The effectiveness of chemical sterilizing agents, when used in conjunction with the normal sanitizing treatments, in reducing the bacterial counts of freshly washed cans.

## REVIEW OF THE LITERATURE

The literature pertaining to the washing and sterilization of milk cans is so voluminous that reference will be made only to those reports which are considered pertinent to this study.

The two common types of mechanical can washers in general use today are the rotary and the straight-way. In 1929 Farrall[3] made a study of mechanical can washers and the conditions affecting their efficient operation. The observations which he made at that time later affected the design of can washers, particularly in the use of superheated steam to secure maximum heating and rapid drying of the can.

Weber[8] in 1938 conducted a survey of can washers and found many in use which had faulty features of construction including jets which were too small, pressures and volumes of steam and water which were inadequate, and absence of thermometers and pressure gauges. To aid in correcting the deficiencies and to increase the effectivness of the washer, he wrote specifications for each stage of operation of the washer.

Important factors, not related to the design of the washer, which affect the bacterial count of the washed can are: physical condition of the can, temperature and condition of storage of the can, and the sanitary condition of the can washer.

Russell,[6] in 1897, cautioned against the use of cans which were rusted or patched or had open seams, in order to avoid bacterial contamination of the milk. Since that time numerous investigators have eleborated upon that recommendation.

Thornton *et al.*[7] considered that the lower bacteria count observed in milk during cold weather was due, not only to better cooling of the milk, but also to the lower temperature at which the cans were stored.

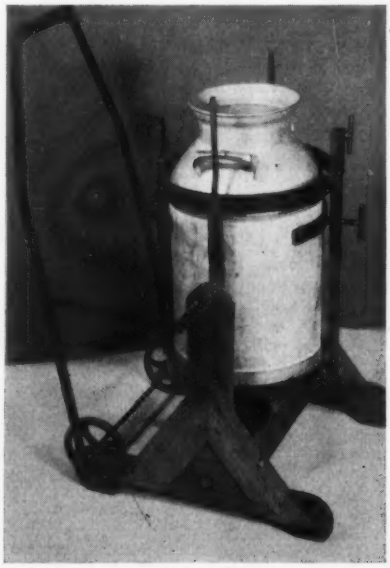

FIGURE 1
Mechanical Rinsing Device

Farrall[3] secured data which clearly demonstrated the importance of keeping the interior of the can washer clean and free from scale deposits. He reported that three cans washed in a neglected washer averaged over 400,000,000 bacteria per can; whereas after the unit was cleaned, cans were obtained which averaged only 5,600.

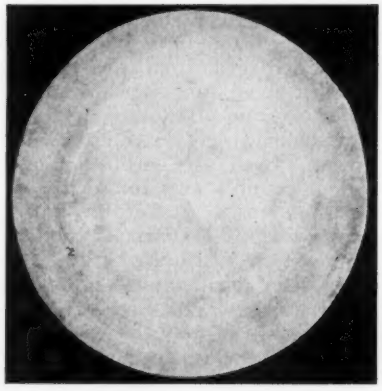

FIGURE 2
Universal Can Lid with Gasket Covering

## EXPERIMENTAL METHODS AND EQUIPMENT

The bacterial counts of the cans were determined by using a controlled rinse-technique and plating the rinse solution according to the standard agar plate method procedure.[1] Controlled rinsing of the cans was achieved by revolving

[1] The data are from a study made by G. W. Reinbold on a fellowship grant from the Diversey Corporation, Chicago, Illinois.
[2] Present address—Kraft Foods Company, Research Laboratories—Glenview, Ill.
[3] Present address—Kraft Foods Company, Research Laboratories—Glenview, Ill.

them in a mechanical rinsing device made from a ten gallon vertical barrel-type churn illustrated by figs. 1 and 2. A steel frame, in which the can was placed and clamped down, replaced the churn. A smooth, circular steel plate fitted with a rubber gasket served as an interchangeable lid because a regular milk can lid did not provide a sufficiently tight seal to withstand the pressure developed during agitation. This lid was held securely in place on the can by a cross bar which in turn was bolted to the frame.

To make a rinse test the following procedure was used: a can was placed in the holding frame and 400 ml. of buffered sterile distilled water containing sodium thiosulfate was poured into the can.[2] Before being used, the lid was sterilized in a solution containing 200 ppm of available chlorine and then rinsed with the buffered sterile water containing sodium thiosulfate. The interchangeable lid was then clamped securely in place. The can was revolved forty times—twenty times in a clockwise direction and twenty times counterclockwise. The rinse solution was drained into a sterile flask, after a few milliliters had flushed the pouring lip of the can. When the rinse samples could not be plated immediately, they were stored in an ice-water bath. The standard plate count per milliliter of the rinse solution multiplied by 400 was considered as the total bacterial count of the can.

Milk cans were either tested immediately or within thirty minutes after being discharged from the washer. However, those cans which were incubated to demonstrate bacterial growth during holding were tested after 24 or 48 hours. In all cases, incubation times and temperatures were recorded.

The can washer used in the experiments described in Parts II and III was the one regularly used at the University dairy plant. It is a Rice and Adams rotary washer, style 241, and has a capacity of three cans per minute. The detergent added to the wash tank solution was a commercial product containing soda ash, trisodium phosphate, a polyphosphate, and a wetting agent. At the beginning of the washing period for forty milk cans, the total alkalinity of the wash solution was approximately 0.25 percent and the concentration of the free sodium hydroxide was 0.05 percent. At the end of the washing period, the free sodium hydroxide was approximately 0.03 percent. The Nafis alkali testing apparatus was used. Usually, a pH of 11 was maintained. The wash solution was plated daily before use and at times at the end of the run.

Temperature readings on a test can were made with a Leeds and Northrup thermocouple potentiometer. Holes were bored in the bottom, side, and shoulder of the can, and copper-constantan thermocouples inserted. Temperature readings were made at these points on the can surface during the washing operation.

TABLE 1

RECOVERY BY CONTROLLED AGITATION RINSE TEST, OF ORGANISMS ADDED TO STERILE CANS

| *Bacteria added to sterile can* | *Bacteria recovered from can* | *% Recovery* |
|---|---|---|
| 960,000 | 895,000 | 93 |
| 3,120,000 | 4,120,000 | 132 |
| 3,690,000 | 2,080,000 | 56 |
| 54,000 | 56,000 | 104 |
| 45,000 | 37,000 | 82 |
| 15,000 | 18,000 | 120 |
| 2,470,000 | 4,040,000 | 163 |
| 1,770,000 | 2,140,000 | 121 |
| 1,880,000 | 2,770,000 | 147 |
| 2,090,000 | 2,440,000 | 117 |
| 3 ml. sterile water | 0 | 0 |
| Average—1,609,000 | 1,860,000 | 115 |

## EXPERIMENTAL RESULTS AND DISCUSSION

### Recovery Tests of Added Organisms

The controlled agitation rinse method of ascertaining the bacterial count of a milk can was adopted in preference to other testing methods because more uniform as well as more accurate results could be obtained. Since bacteria are not uniformly distributed over the surface of a can, a method such as a contact agar disc [5] or a cotton swab,[4] which only measures the contamination on a small portion of a can, would not give as accurate a determination of the total bacterial count of the can as would a rinse method.

By using the controlled agitation rinse technique it was determined that an average of 115 percent of added test organisms which were spread over the surface of a sterilized ten gallon milk can were removed by the first rinsing. The range in recovery tests, however, varied from 56 to 163 percent. The breaking of clumps of organisms by the rinsing agitation is probably responsible for indicating a recovery greater than 100 percent. This condition would also tend to show high counts for the commercial cans tested. Data from the recovery tests are shown in table 1.

*I. Bactericidal Efficiency of the Treatment Received by Milk Cans in Commercial Mechanical Can Washers.*

A survey of the bacteriological condition of freshly washed milk cans was made at thirteen Illinois dairy plants. Three hundred and four cans were tested by the controlled agitation rinse method immediately after they had been washed in mechanical washers. The cans were representative of those being regularly used for transporting raw milk. In addition to securing bacteriological information, another purpose of the survey was to secure data regarding the relation of: the physical condition of the can, the amount of residual moisture, the presence of milk stone, and the type of washer, to the bacterial count of freshly washed cans.

The bacteriological results of the survey are summarized in table 2. No cans were found to be free from bacteria when discharged from the washer even though in certain washers the cans had been exposed to very high temperatures. Only 54 percent of the 304 cans tested were found to have a bacterial count of less than 40,000 per can. Furthermore, wide variations were noted in the bacterial count of cans even though they were tested consecutively in order of discharge from the washer.

TABLE 2

SUMMARY OF THE BACTERIAL COUNTS IN FRESHLY WASHED MILK CANS

| *Range in S.P.C.*[1] *per can* | *Number of cans tested at each dairy plant* | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Plant* | *A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *I* | *J* | *K* | *L* | *M* |
| 1 to 10,000 | 46 | 1 | 6 | 5 | 0 | 20 | 0 | 0 | 0 | 0 | 2 | 2 | 2 |
| 10,001 to 40,000 | 10 | 9 | 21 | 3 | 0 | 14 | 2 | 5 | 1 | 2 | 4 | 5 | 5 |
| 40,001 to 100,000 | 4 | 8 | 3 | 2 | 0 | 21 | 2 | 2 | 2 | 2 | 1 | 2 | 2 |
| 100,001 to 1,000,000 | 6 | 7 | 4 | 3 | 8 | 18 | 2 | 1 | 3 | 0 | 3 | 0 | 0 |
| Over 1,000,000 | 2 | 3 | 0 | 3 | 3 | 19 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| Percent under 40,000 | 82 | 36 | 79 | 50 | 0 | 37 | 33 | 63 | 17 | 40 | 60 | 70 | 70 |
| Percent over 40,000 | 18 | 64 | 21 | 50 | 100 | 63 | 67 | 37 | 83 | 60 | 40 | 30 | 30 |

[1] S.P.C. Standard Plate Count at 37° C.

### Relation of Physical Condition of Can to Bacterial Count

It is generally assumed that cans in good physical condition add fewer bacteria to milk than cans in poor condi-

tion. A record was made of the physical condition of all cans tested. Cans which had neither dents, broken seams, a rusty interior, nor milk stone were classified as being in good condition. Cans which did not possess those characteristics were classified as being in poor condition. Only 53 percent, or 162 of the 304 cans, were classified as being in good condition; the remainder were in poor condition. Furthermore, only 57 percent of the cans which were in good condition had a bacterial count of 40,000 or less; at the same time, 48 percent of the cans which were in poor condition also indicated a bacterial count of 40,000 or less. It is obvious that in these freshly washed cans poor physical condition was not an indication of a highly contaminated can. However, data obtained later in Part II showed that a broken seam in a can was responsible for a high bacterial count.

### Relation of Residual Moisture to Bacterial Count

Moisture remaining in washed milk cans favors the growth of bacteria which are present and viable. Milk cans, which were tested to determine the weight of residual moisture, showed wide variation in the amount retained following the washing and drying operations. The moisture content was determined by placing a petri dish containing a weighed amount of a drying agent (magnesium perchlorate) inside a can, then sealing the can with moisture-proof tape, and after twelve hours removing the desiccant and re-weighing it. The increase in weight was considered to be the weight of residual moisture in the can.

The moisture content of nine cans at plant A, where a new type of straight-way washer was used, averaged 1.0242 grams. The range was 0.7508 to 1.3340 grams. All cans which were tested appeared "dry" when discharged from the washer as well as after being cooled to room temperature.

At plant B, where a rotary washer was used, some cans appeared to be dry while others contained visible droplets of moisture. Three cans selected at random, contained 2.2912, 13.9494, and 17.3268 grams of moisture respectively.

Warm air holds more moisture than cold air. Hence, some investigators have recommended removing the warm air left in a can after drying with cold air in order to prevent condensation of moisture within the can. A late model straight-way can washer at plant G had a cooling section added to accomplish this. The cans were cooled by three brine-cooled air blasts. The residual moisture in ten cans, selected at random for testing, was lower and more uniform than in any group of cans from any other washer. The average moisture content was 0.7108 gram per can with a range of 0.4960 to 0.9095 gram.

Rinse tests of the cans at plant G showed 67 percent of them to have a bacterial count of over 40,000. Moreover, all cans contained a water scale and rust deposit which was due to a very high mineral content water. Only two other plants showed a greater percentage of high count cans.

Low residual moisture at the time the can is discharged from the washer is desirable, but it is not necessarily an index of a low bacterial count in the can.

### Relation of Milk Stone to Bacterial Count

Milk stone in milk cans has been thought to be a very important source of bacterial contamination. During the study it was demonstrated that the bacterial count of freshly washed cans containing milk stone was usually no higher than of cans free from milk stone. Bacterial plate counts of milk stone scraped from cans showed it to contain 30,000 to 40,000 bacteria per gram. However, when this material was mixed with water and incubated at 70° F for 24 hours, an extremely high count was obtained. Hence, it its entirely possible that milk cans containing milk stone and considerable residual moisture would have a high bacterial count at time of use, depending of course on the temperature and time of incubation and species of organisms contaminating the deposit.

### Relation of Type of Washer to Bacterial Count

The mechanical washers in the plants were of three types, namely: straight-way washers using an acid detergent, straight-way washers using an alkaline detergent, and rotary washers using an alkaline detergent. Table 3 summarizes the bacterial counts of the freshly washed cans from the three types of washers.

The straight-way washers with an acid detergent delivered more cans having low bacterial counts than the other two types. Evidence to be presented in Part II would indicate that this satisfactory condition was made possible by subjecting the cans to higher temperatures of heat treatment than in the other two types of washers.

## II. *Factors Influencing the Bactericidal Efficiency of Mechanical Can Washers*

### Contamination of Milk Cans by the Can Washer

Bacteria are introduced into milk cans mainly by the milk and the can washer. Viable organisms are found in freshly washed cans because not all are destroyed by the bactericidal treatment of the washer, and because others are added by certain of the washing operations in the machine.

The number of bacteria, added to milk cans by the wash solution, was determined from the results of tests on 36 sterile cans to average 17,300 per can. The test cans were sterilized in an autoclave at 121° C for 30 minutes. After the washing of 40 regular milk cans, the test cans were run through the washer omitting the cold water rinse. The wash solution during the entire operation was maintained at 145° F. The arithmetical average of the bacterial plate counts of the wash solution during the tests was 1,200 per ml. The range of the bacterial counts was between 100 and 5,000. When rinse tests were made on the sterilized test cans after they had been washed, the average bacterial count per can was 17,300. The range for the 36 cans was between 780 and 138,000.

Tests also showed that prolonged washing of a can in the rotary washer

TABLE 3

SUMMARY OF BACTERIAL COUNTS IN FRESHLY WASHED CANS IN RELATION TO TYPE OF WASHER

| *Range in S.P.C. per can* | *Type of washer* | | |
|---|---|---|---|
| | *Acid*[1] *S/A* | *Alkali*[2] *S/A* | *Alkali rotary* |
| 1 to 10,000 | 51 | 20 | 13 |
| 10,001 to 40,000 | 20 | 16 | 45 |
| 40,001 to 100,000 | 10 | 23 | 18 |
| 100,001 to 1,000,000 | 12 | 18 | 25 |
| Over 1,000,000 | 5 | 20 | 8 |
| Percent of total under 40,000 | 73 | 37 | 53 |
| Percent of total over 40,000 | 27 | 63 | 47 |

[1] Straight-way. Acid detergent.
[2] Straight-way. Alkali detergent (only 2 units tested).

provided no assurance of a can free from bacteria. For example, tests were made on a can which had been washed continuously for one hour, except at the end of each fifteen minute period it was tested by the rinse method. The bacterial counts at the end of each interval ranged between 1,900 and 38,000. The counts fluctuated and showed no trend to increase or decrease during the one-hour washing period. The temperature of the wash solution was 145°F. It had a bacterial count of 250 per ml. at the end of the test period.

The hot air blast used for drying was found to be an important source of contamination for freshly washed cans. Twelve sterilized test cans were allowed to pass over the sterile rinse jet (hot water and steam mixture) plus the hot air blast, and the average increase in count for the 12 cans was 1,300, when the plates were incubated at 37° C. Duplicate plates incubated at 20° C showed the count to be 4,700.

Another source of contamination in can washers other than the hot air was found to be the organic and inorganic deposits which accumulate on the washer. The average plate count of 10 samples of inorganic scale taken from a rotary washer using an alkaline detergent was 8,300 per gram. Also, one sample of grease-like material taken from a rotary washer using an acid detergent gave a count of 217,000,000 per gram.

### Effect of Temperature on the Wash Solution on the Bacterial Count of Cans

Since it had been demonstrated that the wash solution was the most important source of bacterial contamination for sterile cans, a series of tests was made to determine the specific role of the temperature of the wash solution in controlling the bacterial count of the solution and the resulting contamination of the cans. Four test cans were selected to be washed for twenty consecutive days having the wash solution controlled at 140° F, 150° F, 160° F, and 175° F respectively. In addition, another test was made to determine the effect of a pre-rinse at 160°–175° F instead of a cold water rinse. The wash solution was maintained at 140° F during this twelve-day trial.

Two of the test cans were new. Two were old, as well as being in poor physical condition, having rust spots, dents, and excessive milk stone. During the day the cans were stored in a cold room at the University dairy-farm milk house, then filled with cold (50°F) milk at night, returned to the cooler, and delivered to the University dairy plant the following morning. The test cans were the first cans to be washed through the machine each morning. Immediately following washing, they were subjected to the rinse test.

The effectiveness of a high temperature in the wash solution in reducing the bacterial count in milk cans is conspicuous. When the temperature of the wash solution was 140° F, 73 percent of the total bacterial counts obtained on all the test cans were 40,000 or less. However, only 62 percent of the counts from the cans in poor condition were 40,000 or less; whereas 85 percent of the counts from the cans in good condition were 40,000 or less.

On the other hand, when the temperature of the wash solution was increased to either 160° or 175° F all cans, regardless of physical condition, had a low bacterial count. A temperature of 160° F in the wash solution with the detergent and type of washer used, seemed to be critical, for 96 percent of all the bacterial counts on the test cans were considerably under 40,000 when this temperature was maintained. Almost no further reduction occurred when the temperature of the wash solution was increased to 175° F. A summary of the data obtained for each temperature for each test period is presented in table 4.

The pre-rinse at 160°–170° F was also effective in reducing the bacterial counts of the cans. If the counts on can number 2 which developed an open seam are omitted, the bacterial counts of the other three cans compare favorably with the results which were obtained when the temperature of the wash solution was maintained at 160° F. No milk stone was observed in the new cans, where its formation would be readily noticed, during any of the test periods while the cans were subjected to higher than normal temperature.

Measurements of the temperature changes occurring in a milk can during the washing, sterilizing, and drying operations was made with a thermocouple and a Leeds and Northrup thermocouple potentiometer.

TABLE 4

AVERAGE BACTERIAL COUNT OF CANS WHEN WASH SOLUTION WAS MAINTAINED AT DIFFERENT TEMPERATURES

| *Can no. and condition* | *Temperature of wash tank solution* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *140° F* | | *150° F* | | *160° F* | | *175° F* | | *160–170° F pre-rinse, 140° wash* |
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* | *A* |
| 1, Poor | 80,300 | 29,200 | 21,800 | 1,620 | 4,830 | 425 | 3,340 | 446 | 10,500 |
| 2, Poor | 43,000 | 17,600 | 15,100 | 2,060 | 6,690 | 523 | 6,690 | 446 | 243,000 * |
| 17, Good | 27,700 | 4,350 | 35,700 | 501 | 5,520 | 567 | 5,520 | 390 | 8,330 |
| 18, Good | 34,200 | 1,320 | 37,200 | 1,110 | 3,120 | 390 | 3,120 | 390 | 5,880 |
| Wash tank solution per ml. | 1,370 | 69 | 172 | 21 | 26 | 17 | 23 | 18 | 1,800 |
| Average bacterial count for | | | | | | | | | |
| Cans 1 and 2 | 61,650 | 23,400 | 18,450 | 1,840 | 5,760 | 474 | 5,015 | 446 | 127,000 * |
| Cans 17 and 18 | 30,950 | 2,835 | 36,450 | 806 | 4,320 | 479 | 4,320 | 390 | 7,110 |
| Combined averages of all cans | 46,300 | 13,118 | 27,450 | 1,323 | 5,040 | 476 | 4,668 | 418 | 66,900 * |

A: Total S.P.C. per can at 37° C.
B: Total S.P.C. per can at 37° C calculated after laboratory pasteurization at 145° F for 30 minutes of can rinse solution.
* Seam opened in can no. 2 causing noticeably higher counts.

The temperature at the shoulder of the can changed as follows:

| | | | | |
|---|---|---|---|---|
| Temperature of wash solution..... | 140° F | 150° F | 160° F | 175° F |
| Can shoulder temperature after washing... | 134.6° | 141.8° | 151.7° | 165.2° |
| Can shoulder temperature after steaming.. | 167.9° | 176° | 176° | 176° |
| Can shoulder temperature after hot air blast | 104° | 105.8° | 105.8° | 107.6° |

The temperatures to which the can is heated and the total length of time the can is exposed to high temperatures are extremely important factors in securing cans of low bacterial counts immediately following washing.

III. *The Effectiveness of Chemical Sterilizers in Reducing Bacterial Contamination in Freshly Washed Cans.*

The experiments in Parts I and II showed the following results: that large numbers of bacteria in milk cans survived the washing and sterilizing treatments, and that the wash solution added bacteria to the cans to be washed. To determine the possibility of correcting these defects the following experiments were made: first, the injection of a chlorine solution mixed with steam so as to reduce the bacterial survival in the cans; second, the addition of a quaternary ammonium compound to the wash solution to lower the bacterial count and thus reduce the contamination added by the washing solution.

### Injection of Chlorine and Steam into Cans

A straightway washer, using an alkaline wash, was selected as the test unit for the trial with the chlorine injector. Previous to the installation of the chlorinating device, control data were collected by making rinse tests on 92 cans. Following the control period, the chlorinator was attached to the first steam jet so that approximately 30 milliliters of a 500–700 ppm chlorine solution were injected when the cans were steamed. Injection of the chlorine solution did reduce the bacterial count of the freshly washed cans; during the control period, only 37 percent of the freshly washed cans had a bacterial count of 40,000 or less, but when the chlorinator was used, 78 percent of the cans showed a bacterial count of 40,000 or less. Data obtained during these trials are recorded in table 5.

Although the bacterial counts of the chlorinated cans were significantly lower following washing, they did not remain so. Sixty-six chlorinated test cans were held in a room, which ranged in temperature during a 24 hour period from 50° to 70° F. At the end of 24 hours, 16 cans were subjected to the bacterial rinse tests, and the remainder were tested after 48 hours. Fifty percent and 38 percent respectively of the cans after the 24 and 48 hour incubation period had bacterial counts of 40,000 or less. Only 10 percent of the control cans which had not received chlorination but which had been incubated under comparable conditions had a bacterial count of 40,000 or less. Although the injection of the chlorine solution with the steam did reduce the immediate bacterial survival in the can and produced a freshly washed can of lower bacterial count, its residual effect was not of sufficient duration to be beneficial. On the other hand, the temperature of storage of a washed can was found to be highly significant in determining its bacterial count. Tests showed that the bacterial counts of cans stored for 48 hours at 50° F were lower than the counts of similar cans tested directly from the washer. Furthermore the low storage temperatures for 48 hours had a greater inhibitory effect on bacterial growth than did the injection of chlorine into the cans. The experimental data are recorded in tables 5 and 6.

TABLE 5

EFFECT OF THE INJECTION OF CHLORINE SOLUTION INTO CAN AT STEAMING ON THE BACTERIAL COUNT

| *S.P.C. per can at 37° C* | *Control cans tested immediately* | *Chlorinated cans tested immediately* | *Control cans tested after 24 hrs. at 50–70° F* | *Chlorinated cans tested after 24 hrs. 50–70° F* | *Chlorinated cans tested after 48 hrs. 50–70° F* |
|---|---|---|---|---|---|
| | *Number cans* | *Number cans* | *Number cans* | *Number cans* | *Number cans* |
| 1–10,000 ..... | 20 | 34 | 0 | 4 | 6 |
| 10,001–40,000 ..... | 14 | 9 | 2 | 4 | 13 |
| 40,001–100,000 ..... | 21 | 2 | 2 | 1 | 4 |
| 100,001–1,000,000..... | 18 | 8 | 9 | 2 | 8 |
| Over 1,000,000..... | 19 | 2 | 8 | 5 | 19 |
| Percentage under 40,000 | 37 | 78 | 10 | 50 | 38 |
| Percentage over 40,000 | 63 | 22 | 90 | 50 | 62 |

### The Use of a Quaternary Ammonium Compound in the Wash Solution

A low bacterial count in the wash solution is desirable in order to reduce or prevent the contamination of a washed can. The wash solution in various mechanical can washers becomes heavily contaminated with bacteria and organic matter through continued use. To determine the effectiveness of a quaternary ammonium compound in maintaining a low bacterial count in the wash solution as well as the effect of the latter on the bacterial counts of the washed cans, a series of tests was made.

TABLE 6

INFLUENCE OF INCUBATION TEMPERATURE ON THE BACTERIAL COUNT OF CANS NOT TREATED WITH CHLORINE

| *S.P.C. per can at 37° C* | *Control cans tested immediately* | *Cans tested 48 hours after washing* | |
|---|---|---|---|
| | | *Held at 50° F* | *Held at 50°–70° F* |
| | *Number cans* | *Number cans* | *Number cans* |
| 1–10,000 ..... | 20 | 2 | 0 |
| 10,001–40,000 ..... | 14 | 11 | 2 |
| 40,001–100,000 ..... | 21 | 1 | 2 |
| 100,001–1,000,000..... | 18 | 2 | 9 |
| Over 1,000,000..... | 19 | 2 | 8 |
| Percentage under 40,000 ..... | 37 | 72 | 10 |
| Percentage over 40,000..... | 63 | 28 | 90 |

The experimental conditions were comparable to those described for Part II. In addition to the regular alkaline washing compound in the wash tank, one pound of the dry crystalline germicide was added to 50 gallons of washing solution. The temperature of the tank was maintained at 140° F. The test cans 1, 2, 17, 18, were the same as previously used, and they were washed daily, for a period of 19 days, at the beginning of the washing period for 40 other milk cans.

A summary of the results obtained from these tests is presented in table 7. Calculations made from the data show that 77 percent of the tests obtained on the cans had a bacterial count of 40,000 or less. However, the can with the open seam was responsible for 13 of the 19 counts obtained above 40,000. If all the bacterial counts from can 2 were omitted, then 93 percent of the tests would be 40,000 or less. In Part II, when the wash solution was maintained at 140° F and only an alkaline compound was used, 73 percent of the bacterial counts were 40,000 or less. Hence, there was a noticeable improvement in number of low bacterial count cans produced—when the quaternary ammonium compound was used under the favorable conditions of the test. Although this quaternary ammonium compound was effective in producing low counts in the wash solution at the beginning of a washing period, its effect was lost before 40 cans were washed. The average bacterial count at the beginning of the washing period was 47 per ml. However, at the end it had increased on an average to 27,000 organisms per ml. and only 45 to 50 cans had been washed.

TABLE 7

RANGE IN BACTERIAL COUNTS OF CANS WHEN WASHING SOLUTION CONTAINED QUATERNARY AMMONIUM COMPOUND

| *Can no.* *Condition* | *Range of total S.P.C. per can* | | | | |
|---|---|---|---|---|---|
| | *1–10,000* | *10,001–40,000* | *40,001–100,000* | *100,001–1M* | *Over 1M* |
| 1-poor | 14 | 3 | 2 | .. | .. |
| *2–poor | 3 | 3 | 4 | 7 | 2 |
| 17–good | 15 | 3 | 1 | .. | .. |
| 18–good | 16 | 3 | .. | .. | .. |
| Last can washed (40th) | 2 | 3 | .. | 1 | 2 |

Wash solution before use—(average of 19 counts), 47 organisms per ml.
Wash solution after use—(average of 10 counts), 27,800 organisms per ml.
* Open seamed can which caused the greatly increased bacterial counts after washing.

## SUMMARY AND CONCLUSIONS

In Part I a report was made of a survey of milk can-washing operations in 13 milk plants. Of the 304 cans tested directly from the washer by a standardized rinse method, only 54 percent were found to have a bacterial count of 40,000 or less. The need for improvement in can washing operations so as to assure cans with a low bacteria count is apparent.

The bacterial counts of the cans which were examined varied widely even when they were tested consecutively from the same washer. The results of the survey showed that with the freshly washed cans tested, except for an open seam defect, the physical condition of the can was not an accurate index of its bacteriological condition. Forty-two percent of the cans which were *free* from rust, corrosion, milk stone, or any other deposit contained more than 40,000 bacteria per can. On the other hand, only 53 percent of the cans which were in poor physical condition and had the above defects contained more than 40,000 bacteria per can. The moisture content of milk cans which were dry to visual inspection varied from 0.75 to 1.33 grams. Cooling the cans with a blast of cold dry air reduced the moisture content to 0.49 to 0.90 grams.

The bacterial count of milk stone scraped from cans was determined to be approximately 40,000 per gram. Although the bacterial count of freshly washed cans containing milk stone was never observed to be unusually high, the milk stone was found to harbor bacteria which would grow when conditions were favorable.

In Part II, a controlled study was made with a rotary washer, to determine the factors influencing the final bacterial count obtained in a milk can.

When previously sterilized, cans were washed with 145° F wash solution in the test rotary washer, an average of 36 tests showed them to contain 17,300 bacteria per can after washing. The hot air blast added an average of 1,300 organisms to the can. The remainder of the bacteria had been added by the contaminated wash solution.

Water scale in the wash tank was found to be a source of contamination for the wash solution.

The bacterial counts of the wash solution and the cans were conspicuously reduced by increasing the temperature of the washing solution to 160° F. Temperatures of 140° F, 150° F, 160° F, and 175° F in the washed solution were compared as to their effectiveness in lowering the bacterial count in the washed can. When the test cans were washed with the wash solution at 140° F, only 73 percent of the bacterial counts obtained on the cans were 40,000 or less. When the temperature was raised to 150° F, the percentage of satisfactory cans increased to 91 percent, and when 160° F was used, 96 percent of the cans met the standard of 40,000 or less. Furthermore, there was only a small difference in bacterial counts in the cans and wash solution when 175° F was used as compared with 160° F.

In Part III, the effectiveness of chemical sterilizers in increasing the sterilization treatment of can washing operations was determined.

Thirty milliliters of 500 to 750 ppm of chlorine were injected into cans by the first steam jet on a straight-way washer. Previous to the use of the chlorine injection, only 38 percent of the cans washed in the machine met the standard of 40,000 or less bacteria per can. During the use of chlorine, 78 percent of the cans met the standard. However, the effect of chlorine was not permanent since cans treated with the chlorine had essentially the same counts after 48 hours as those cans which were not treated. When a quaternary ammonium compound was added to the wash solution to control the bacterial count of the solution, its effect was soon lost. No reduction in count of the wash solution was obtained after one hour of use.

(Continued on page 41)

# THE PROBLEM OF BACTERIOPHAGE IN THE DAIRY INDUSTRY[1, 2]

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FERMENTATION of milk sugar, lactose, by lactic acid bacteria has been employed for hundreds of years in production of a variety of dairy products such as cheeses and fermented milks. The formation of lactic acid in such products is essential for desired flavor, physical change, and preservation. Lack of sufficient acid development may result in an inferior or worthless finished product.

It now is an accepted fact that destruction of lactic acid bacteria by bacteriophage, a bacterial virus, represents one of the most important causes of insufficient acid development in manufactured dairy products. This is an industrial problem and has parallels in other industrial fermentations. Examples are bacteriophage (phage) lysis of: *Clostridium* species in the acetone-butanol fermentation; *Bacillus polymyxa* in production of 2, 3-butanediol; and *Streptomyces griseus* in streptomycin production. The decentralized nature of the dairy industry and wide variety of lactic acid streptococci employed as starter cultures in dairy products greatly complicate the bacteriophage problem for the dairy plant operator. Added to this is the ubiquity of lactic acid streptococci in nature which thus may provide a vast reservoir of phage races capable of attacking the starter cultures employed in the dairy plant.

Recognition of phage destruction of lactic acid bacteria is not a recent development. Hadley and Dabney[9] in 1925 described phage lysis of *Streptococcus lactis*. Whitehead and Cox[32] in New Zealand in 1934 reported inhibition of Cheddar cheese starters by an agent introduced into the culture medium by aeration. They soon identified the agent as phage.[33] Their observations were confirmed by investigators in France, Australia, United States, Canada, and England.[1, 2, 16, 17, 20, 30] The problem appears to be universal in the dairy industry. It also appears to be related to some extent to the advent of pasteurization of milk for dairy products. Raw milk usually carries sufficient numbers of lactic acid (milk-souring bacteria) that may substitute for those added in the form of a cultivated starter culture in the event the latter are attacked by phage. However, if the natural lactic acid flora is removed from the milk by pasteurization, and the added starter bacteria are destroyed by phage, there will be partial or total failure of the lactic acid fermentation in the product.

## DAIRY PRODUCTS AFFECTED BY BACTERIOPHAGE

Phage has been reported most frequently in connection with Cheddar type cheese. In the manufacture of this product, partial inhibition of lactic acid production frequently is referred to as a "slow vat" and nearly complete inhibition as a "dead vat." In addition to disruption of the carefully timed operating schedule in the cheese plant, production of insufficient lactic acid also leads to undesirable fermentations with consequent abnormal fruity, rancid, and putrid flavors, and excessive gas formation. The low pH attained in a normal, vigorous lactic acid fermentation prevents growth or toxin formation by chance pathogens that might be present in the early stages of manufacture. Inhibition of the lactic acid bacteria removes that protective factor. This problem always represents a potential hazard in cheese like Cheddar because the milk and curd are held for several hours at a temperature favorable for growth and toxin production of some pathogens. These statements should not be construed as indicating that disease-producing organisms commonly are associated with cheese and similar products. Actually, in this country, rigid supervision of production together with pasteurization and the subsequent destruction of chance pathogens by the lactic acid formed in cultured milk products all contribute to make these foods some of the safest that are consumed.

Inhibition of lactic acid bacteria occurs in products other than Cheddar cheese. Types such as Limburger, brick, Roquefort or blue, and many others may be affected in the same manner. Serious losses due to phage have been suffered in manufacture of cottage cheese. The same is true of cultured buttermilk. Phage has caused serious difficulty in manufacture of some by-products such as baby foods that employ a lactic fermentation. Unquestionably the losses due to this agent have been greater in the dairy industry than is generally realized. Many technicians and operators do not recognize phage outbreaks when they occur. Isolations of phage continue to be made from dairy plants that have never suspected it as a cause of their difficulties with slow acid production.

Phage attacks have been reported thus far for only three species of bacteria important in cheese and other cultured milk products. Two of these, *S. lactis* and *S. cremoris*, are widely employed as single strain or mixed cultures for acid production in the above-mentioned dairy products. A recent report[19] of isolation of a phage capable of lysing *Leuconostoc citrovorum* may explain some instances of sudden loss in aroma production noted in mixed cultures of the lactic acid and aroma bacteria. *L. citrovorum* and *Leuconostoc dextranicum*, are grown as a mixed culture in association with *S. lactis* or *S. cremoris*. The *Leuconostoc* species ferment citric acid in milk and milk products to acetylmethylcarbinol and biacetyl. The latter compound contributes the characteristic pleasing butter aroma or bouquet to many cultured milk products. Without the minute traces of biacetyl, they would taste harsh and flat.

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[1] One of a series of nine papers on viruses presented at the Eleventh Annual Biology Colloquium, Oregon State College, April 29, 1950.

[2] Published as Technical Paper No. 641 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution of the Department of Bacteriology.

A curious fact is the absence in the literature of any report of phage associated with *Streptococcus thermophilus* and lactobacilli like *L. bulgaricus* and *L. lactis* in manufacture of Swiss-type cheeses and some fermented milks. These organisms have higher optimum and maximum growth temperatures than the streptococci commonly attacked by phage; in most other respects *S. thermophilus* closely resembles *S. lactis* and *S. cremoris*.

## PROPERTIES OF *S. CREMORIS* AND *S. LACTIS* PHAGE

*Morphology.* Electron microscope studies of phage strains active against *S. lactis* 122–4 indicate the particles to be sperm-shaped.[3, 27] The average dimensions observed were as follows: Diameter of head, about 70 $\mu$; length of tail, 150 to 160 $\mu$; width of tail, 20 $\mu$; and over-all length, 220 to 230 $\mu$. Nine strains of phage were so nearly alike that no morphological difference between them was discernible. Electron micrographs of phages associated with cells indicated the phages to be oriented with the tail toward the bacterial cell.

*Estimation of Phage Population.* The common means of establishing presence and concentration of phage for lactic acid streptococci is by dilution-sensitivity tests and by plaque formation. In the sensitivity test respective dilutions of phage are inoculated to suitable indicator media such as broth, litmus milk, resazurin milk, or methylene blue milk. The highest dilution inhibiting the culture in the milk or causing visible cell lysis (demonstrated by clearing of the medium) in broth provides an estimate of the phage population. In the plaque method, sensitive cells plus phage are spread on the surface of agar plates. Small clear areas on the plates surrounded by normal growth following incubation indicate lysis of cells by phage in those areas, and this provides an estimate of number of phage particles present.

*Nutrient Requirements.* Little is known of the nutrient requirements of various phage strains specific for lactic acid streptococci. The requirements may be different than those of the host cell. One study [5] indicates that certain phage strains for *S. lactis* will not reproduce in synthetic media deficient in calcium although the host developed satisfactorily under the same conditions. The *S. lactis* host-phage system has been shown to require factors not entirely supplied by yeast extract.[4] Potassium phosphate, potassium chloride, sodium chloride, calcium chloride, magnesium sulfate, and sodium acetate promoted lysis of host cells according to their efficiency in promoting phage adsorption by the host cells. Sodium citrate allowed maximum adsorption but inhibited lysis.

*Effect of pH of Medium.* Phage adsorption on *S. lactis* has been shown to be highest at pH 7.0.[3] Lysis was most rapid at pH 7.0, somewhat slower at pH 6.0 and 8.0, and almost completely inhibited below pH 5.0.

*Phage Reproduction at Different Temperatures.* Hunter [10] found that phages for *S. cremoris* showed a wider diversity of reaction to temperature than their homologous organisms. The optimum growth temperature for *S. cremoris* usually is near 30° C. They usually are inhibited to some degree at 37° C. Some phage strains in this study developed as well at 22° as at 30° C. Most phage strains developed more readily at 30° than at 22° C. Some developed more readily at 37° C than at lower temperatures and others were completely inhibited at 37° C. These results are significant from the standpoint of laboratory studies on phage reproduction. They also may explain in part why some phage strains cause more difficulty in Cheddar cheese where manufacturing temperatures range from 30° to 40° C than in other products that employ lower temperatures for growth of lactic acid bacteria.

*Burst Size.* The burst size (average number of phage particles released per infected host cell) of *S. lactis* 122–4 was calculated by Cherry and Watson [4] to be about 70 plaque-forming particles at 30° C in tryptone yeast extract broth at pH 7.0. This is lower than the yields reported for some other organisms, and might be increased under more favorable conditions.

*Heat Resistance.* Results of a number of investigators indicate that phage strains for *S. lactis* and *S. cremoris* appear more resistant to heat than do their host cells.[25] Nichols and Wolf [25] found that active phages usually did not survive 75° C for 7.5 minutes but many were not destroyed at 65° to 67° C for 50 to 60 minutes. Most survived 70° C for 10 to 15 minutes. Cells of *S. lactis* and *S. cremoris* do not survive 71.1° C for 15 seconds. These results emphasize the necessity of high pasteurizing temperatures in preparation of milk for the bulk culture. A minimum exposure of 82° to 88° C for at least 30 minutes is recommended for this operation with the above data in mind. Another significant fact emphasized by these results is that normal pasteurization temperatures employed for cheese milk will not destroy most phage strains entering the plant with farm milk.

*Destruction by Chemical Germicides and Ultraviolet Radiation.* Wolf *et al.*[39] studied effect on air-borne *S. cremoris* phage of hypochlorite, resorcinol, and propylene glycol mists. They concluded that hypochlorites offered the most practical means of destroying air-borne phage. Recommended exposures indicated by the study were a fine mist produced by spraying 4 ml. of a 9 to 12 percent available chlorine solution per 1000 cu. ft. air space at a relative humidity of no less than 70 percent.

Prouty [28] reported destruction of phage for *S. cremoris* following exposure in solution to 200 ppm of quaternary ammonium compounds for a period of two minutes. Studies [26] on comparative effect of quaternary and hypochlorite germicides indicate the hypochlorites to be more effective in destruction of *S. cremoris* phages than quaternaries over a wide pH range. The results indicate that hypochlorites should prove superior to quaternaries for destruction of phage on plant equipment, utensils, and building surfaces. In a study of a number of germicidal substances, Hunter and Whitehead [14] found chlorine and permanganate the most effective against phage.

Experiments on effect of ultraviolet radiation of lethal wave length on *S. cremoris* and *S. lactis* phages [8, 30] indicate that destruction by ultraviolet may be accomplished. However, the long time-exposures required at relatively short distances from the ultraviolet lamp suggest this agent to be impractical for destruction of phage in the dairy plant.

*Phage Adaptation.* The report of Nichols and Hoyle [22] indicates that a phage strain can be adapted to attack a previously resistant host. They were able to adapt a large number of phage strains to lyse selected strains of previously resistant *S. cremoris*. On the other hand, many phage-organism combinations did not respond to the adaptation technique of exposing a resistant host to high concentrations of phage and isolation of the adapted phage from resulting plaques.

*Nascent Phage.* The nascent phage

phenomenon apparently occurs with lactic acid cultures.[1, 10, 24] A nascent phage is one that normally will not attack an organism. However, if a strain of organism sensitive to that phage also is present, the phage may lyse both strains. The nascent phage reaction apparently is not common, but does present a potential hazard when two or more strains of lactic culture are mixed in bulk culture or in the final cultured milk product.

*Lysogenesis in Lactic Acid Bacteria.* Lysogenesis (the production and liberation of phage by a host cell without lysis of that host cell) has never been conclusively demonstrated in cultures of *S. lactis* or *S. cremoris*.[22]

*Phage Carrying Strains of Lactic Acid Streptococci.* Hunter and Whitehead [12, 13, 15] have shown that cultures of lactic streptococci partially resistant to a specific phage strain may grow in association with that strain. As a result of an apparent blocking effect of that phage, the organism is protected from attack by other races of phage. Such cultures have been employed in commercial plants, but after several months other phages appear that attack the phage-carrying cultures. Hunter [12] has also reported that plating out cultures of lactic streptococci on agar and picking resulting colonies will free the organisms of all phage particles.

*Phage Typing.* Nichols and Hoyle [22] have reviewed the studies on attempts to establish phage types of lactic acid streptococci. In a comprehensive series of experiments they succeeded in establishing eleven phage types or patterns for *S. lactis* and *S. cremoris*. In extending these studies they were able to divide the majority of the phages into three serological groups by means of antiphage sera. The knowledge of phage types was believed of value in determining which commercial starters should be employed in cheese plants troubled with certain strains of phage.

*Development of Phage-Resistant Secondary Strains.* A number of workers have reported development of resistant secondary strains following phage lysis of a sensitive lactic acid culture.[1, 12, 20, 31, 34, 35, 38] The use of such strains for starter cultures has been less successful than might be expected. In some studies these strains have proved less active in acid production than the original sensitive host strain. The apparent great number of phage strains existent also has resulted in eventual attack of the resistant secondary strains. In some specific instances development of resistant secondary strains has been successful in coping with polyvalent phage strains established in certain dairy plants.

*Source of Phages for the Lactic Acid Streptococci.* Nichols and Hoyle [22] have reviewed investigations on this subject. Phages for the lactics have been isolated from raw milk entering the plant, from various locations and pieces of equipment in the plant, from cheese, and from by-products such as whey powder. One worker, Maze,[18] insists that phages for lactic acid streptococci are formed in the intestinal tracts of hogs. His claims have not been entirely substantiated by other workers.

## DETECTION OF PHAGE

Methods of detection and isolation are summarized in a number of reports.[1, 2, 6, 7, 11, 12, 20, 22, 24, 25, 34, 36] Presence of bacteriophage in a starter culture or cultured-milk product may be suspected whenever the lactic acid bacteria suddenly slow up or completely fail to grow. Usually in such cases a starter culture from a different source containing other strains of lactic acid bacteria will provide temporary relief from the difficulty, providing no phage-strain specific for the new culture is present. In some cases several strains of phage may be present in the plant. The phage sometimes may be one of multiple specificity and thus may be able to attack a number of different strains of starter organisms.

A few simple tests may be employed in the plant to provide presumptive evidence of the possibility of phage. A few drops of fresh starter may be added to about 10 ml of sterile skim milk in a tube and if the milk fails to coagulate in 24 hours the possibility of phage in the starter exists. If a second tube of milk is inoculated in the same manner and incubated at 86° to 98.6° F, microscopic examinations of the contents can be made at intervals over a period of about 8 hours. If the organisms begin to multiply and then lysis (disintegration of cells) is noted, the evidence is strong that the phage has attacked and destroyed the bacteria. If phage is suspected in cheese manufacture, duplicate tubes or small bottles or flasks containing sterile skim milk may be inoculated with about 0.5 percent of fresh starter. One of the duplicate containers then may be inoculated with 2 or 3 drops of whey from a suspicious vat. The other container serves as a control. The cultures may then be incubated at 86° F for 6 hours and titratable acidity determined. If acid developed is significantly greater in the control container, presence of phage in the whey is strongly suggested.

The most certain method of demonstrating presence of phage in a culture or product is to pass it through a bacteriological filter that will remove all microorganisms. At the same time the culture suspected of attack must be plated on agar and growth from a number of individual colonies transferred to sterile milk or broth to obtain single strains of the culture organisms. Duplicate sterile tubes of milk or broth then may be inoculated with the single-strain cultures and a drop or two of filtrate added to one tube. If the control tube develops acid in significantly greater amounts or at a faster rate than the tube containing filtrate, there is a strong possibility of phage. The titer, or concentration of phage in the filtrate, may be determined by noting presence or absence of inhibition in tubes of milk or broth inoculated with the single strain and varying dilutions of phage. It also is possible to demonstrate phage by smearing or inoculating single-strain culture and filtrate onto agar plates and observing for plaque formation.

The growth from the above broth or milk may be again passed through a sterile filter. If the inhibitory substance can be increased or maintained in concentration by successive filtrations and periods of growth on a susceptible culture, it is bacteriophage. If the inhibitory substance is diluted out and gradually becomes weaker by such successive passages through the filter, it may be an antibiotic. Another means of distinguishing between inhibitory materials is as follows: A tube of the material suspected of containing inhibitory substance may be heated to boiling for five minutes and some of it then added to a tube of milk inoculated with starter culture. If the inhibitory substance is phage, it will be destroyed by the boiling. If it is an antibiotic such as penicillin or antibiotics produced by other lactic streptococci, it will survive the heating and inhibit acid production on subsequent inoculation into the starter culture.

The phage may be isolated from plaques with a sterile needle. Usually three successive passages through plaques with transfer each time to fresh susceptible single-strain culture will purify a phage strain. The resulting

strain of phage may then be a single strain or race or may be of multiple specificity.

### PRACTICAL CONTROL METHODS

The control of bacteriophage in many small, scattered plants throughout the country represents a difficult problem. Recommendations for prevention of phage outbreaks have been presented by many workers.[1, 6, 7, 15, 21, 22, 23, 36, 37, 39]

Since bacteriophage develops upon susceptible bacteria, it will be present not only in cultures or cultured milk products but also on growing organisms on equipment. It may lodge on floors, walls, ceilings, dust, and may even be carried on hands and clothes of workers. Apparently droplet infection from the contaminated product, especially whey, tends to spread it around the plant and even into the starter laboratory if it is located near the processing room of the plant. Whey separators are an especially difficult problem because they throw a fine atomized mist over the plant.

One measure found helpful in some plants has been thorough cleaning followed by hypochlorite treatment of floors and all equipment that comes in contact with the product. Brushing, soaking, or thoroughly spraying all equipment and tools before use with 500 ppm hypochlorite solution is recommended where phage outbreaks occur. Another measure employed to reduce droplet infection is to spray the entire processing room with hypochlorite at the rate of at least 4 ml of a 9 to 12 percent solution per 1,000 cubic feet. The relative humidity of the room should be at least 80 percent if possible for most effective penetration of the chlorine.

Some plants have reduced phage outbreaks and improved uniformity of starter cultures in general by obtaining mother culture daily from a central laboratory. This system greatly reduces the danger of phage contamination of mother culture and enables one laboratory to maintain closer control over the quality and selection of starter strains than would be true in scattered small plants. In some instances the mother culture is sent by air express from the central laboratory.

Another measure consists of removing the starter laboratory to some part of the plant away from the processing room to reduce chances of contamination of culture. In some cases the starter laboratory has been set up some distance away from the plant. Elaborate precautions, such as means for sterilization of the room, maintaining positive air pressure in the room to prevent air currents carrying phage in, and use of specially constructed culture vessels with a small opening for inoculation and water seal of the lid, also have been employed.

If several different cultures can be carried in the laboratory, they can be rotated in such a way that one or two are used one day, another combination the next, and so on. In Cheddar cheese manufacture, as many as eight or ten strains may be carried. Two cultures are grown separately and mixed at the vat on the first day, two other strains the next, and so on. Then the original two are used again and the rotation is repeated. This tends to prevent a build-up of phage for one culture day after day in the plant.

Where facilities are available, tests may be run on whey or other products to determine whether or not phage is accumulating for a certain culture. As soon as evidence indicates such accumulation, another culture is introduced.

Strains of lactic acid bacteria may be made resistant to bacteriophage by repeatedly exposing them to phage and growing the survivors. Such strains may be resistant to numerous phage types, but the possibility of attack by another phage specific for them always exists.

The recent observations of Hunter and Whitehead [12, 13, 15] relative to protection of a starter from other phage strains by growing it in association with a selected phage strain has suggested a possible protective mechanism for the culture. However, as pointed out by the authors, two possibilities may arise in such a circumstance: The culture may lose the protective phage and thus have no means of blocking out other phages capable of attacking it. Further, the observations indicate that occasional phage strains may be encountered that will attack the phage-carrying culture.

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(Continued on page 44)

# FAT DETERMINATIONS IN MILK AND MILK PRODUCTS

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DAIRYMEN are usually paid for their milk and milk products especially on the basis of the fat content. It therefore is important that there should be available a quantitative test for fat that is accurate, safe, and easy to perform.

The official (legal) test in many States for fat in milk and certain milk products has been and is the "Babcock Test". This test presents many difficulties and disadvantages. When the sulfuric acid employed is not of the proper strength, inaccurate findings are obtained. Careless handling of the acid may result in burns inflicted upon the worker. The test bottle with contents must be centrifuged at least two or three times. This is both time consuming and frequently inconvenient. The Babcock technique is satisfactory only for milk and certain creams. Other techniques must be employed for other milk products.

The technique suggested by Schain [1] employs the use of detergents to break down the protective layer, thus allowing the fat globules to become one layer. Schain employs polyoxyethylene sorbitan monolaurate for the non-ionic detergent and dioctyl sodium phosphate for the anionic detergent. One of us has reported on this technique [2] and modifications thereof.[3]

In this investigation, we have employed different detergents comparing them with the Schain method, modifications thereof, and the Babcock technique.[4]

## EXPERIMENTAL

### Reagents

*Coloring Solution.* This is a saturated solution of oil-soluble dye Oil Red O in isoamyl alcohol. Three ml of the clear supernatant solution are mixed well with 100 gm. of non-ionic detergent. Other suitable fat-soluble dyes may be used.

*Solution A.* This is a non-ionic detergent. Any one of the following may be used as *Solution A* and all were employed in this investigation:

| | |
|---|---|
| [5] Tween 20 | [6] Triton A-20 |
| Tween 40 | Triton X-155 |
| Tween 80 | Triton N-100 |
| Tween 85 | |

### Reagents

*Solution B.* This is an anionic detergent. Any one of the following may be used as *Solution B* and all were employed in this study:

| | |
|---|---|
| [7] Tergitol 4T | Tergitol O8 |
| Tergitol 4 | Tergitol P28 |

### Procedure

(a) *Quantity of sample of milk or milk product employed:*

1. Milks (raw, homogenized, pasteurized, skim, buttermilk and chocolate milk)

Weigh 18 grams and employ an official Babcock 8 percent milk test bottle.

2. Creams (sweet or sour)

Weigh 9 grams and employ an official Babcock 9 gram, 50 percent cream test bottle.

3. *Cheeses*

Weigh 4.5 grams and employ an official Babcock 9 gram, 50 percent test bottle. The cheese must be finely divided and warmed (to liquefy wherever possible).

4. Ice Cream

Weigh 9 grams of sample and employ a 20 percent official Babcock ice cream test bottle. The ice cream is warmed and mixed thoroughly. Fruits and nuts, if present, are finely ground.

5. Butter

Weigh 4.5 grams and employ a 9-gram 50 percent official Babcock cream test bottle.

6. Evaporated Milk

Weigh 4.5 or 6 grams of sample and employ an 8 percent official Babcock test bottle or an official 20 percent ice cream test bottle.

7. Sweetened Condensed Milks

Weigh 9 grams of sample and use an official 9 gram 20 percent ice cream test bottle.

(b) *Technique*

(1) A well-mixed sample (amount specified above) was placed in a beaker.

(2) The designated quantity (see table 1) of Solution A (any of the above mentioned non-ionic detergents as marketed) was added to the designated quantity of sample (as given under "a") and both were shaken well until a homogenous mixture was obtained. The amount of Solution A varies depending upon the detergent used. These quantities are as follows:

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TABLE 1

| *Solution A* | *Volume* |
|---|---|
| Tween 20 | 3.5 ml |
| Tween 40 | 2 ml |
| Tween 80 | 2 ml |
| Tween 85 | 4 ml |
| Triton A20 | 4 ml |
| Triton X155 | 4 ml |
| Triton N100 | 4 ml |

(3) A designated amount of Solution B (which is one of the anionic detergents as marketed (see table 2)) was added to the above mixture (under 2) and the contents were mixed well. The amount of Solution B employed depends upon the specific anionic detergent used. The quantities are as follows:

TABLE 2

| *Solution B* | *Volume* |
|---|---|
| Tergitol 4T | 10 ml |
| Tergitol 4 | 10 ml |
| Tergitol 08 | 14 ml |
| Tergitol P28 | 10 ml |

(4) The mixture of sample and detergents was then placed in an official Babcock milk or cream test bottle (depending upon the sample.) The mixture was washed from the neck of the bottle with 1 ml of distilled water.

(5) The bottle and its contents were then placed in a boiling water bath so that the water in the bath is higher than the liquids in the bottle.

(6) The bottle was removed from the water bath after remaining for 5 minutes at boiling-water temperature. Sufficient hot water from the bath was added to the bottle to enable the fat

column to rise in the neck to the top of the graduation marks.

(7) After standing for 15 minutes at room temperature, the percentage of fat was recorded, as in the Babcock technique. If any fat adheres to the walls of the bottle it can be washed down to the fat column by adding 1 drop of N sodium hydroxide solution.

### Findings

The above technique using various detergents has been carried out on numerous samples of raw and homogenized pasteurized milks, buttermilk, skim milk, chocolate, condensed and evaporated milks, cream, ice cream, butter and cheese. In every test, the readings were clear cut and agreed with the Babcock and Schain methods and modifications thereof.

### Modification of Technique

One single solution was prepared with Solutions A and B. All combinations were prepared with the reagents as given in table 1 and in table 2 and this one single solution was used in each instance.

The technique is the same as that described above with the exception that this test replaces steps 2 and 3 by using the single solution containing both solutions A and B.

The only single solutions which gave satisfactory results were Tween 40 as Solution A mixed with either Tergitol 4 or with Tergitol P 28 as Solution B.

### Summary and Conclusion

A method is given, using various anionic and non-ionic detergent combinations, for determining the fat content in milk (raw, pasteurized, plain or homogenized), buttermilk, chocolate milk, skim milk, butter, cream (light and heavy), ice cream, and sour cream.

The fat column obtained by employing these various anionic and non-ionic detergent combinations using the fat soluble dye Oil Red O was clear and distinct, so that a reading could be made quickly and accurately. A large number of samples of different milks and milk products were examined.

The test, in all instances, was found to be accurate, easy to perform and required no extensive laboratory equipment. All findings were compared and agreed in every instance with the official Babcock technique, the Schain method, and the Gershenfeld and Ucko modification of the Schain method.

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# STUDIES WITH SANITIZERS BASED ON QUATERNARY AMMONIUM SALTS

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WITH the increasing knowledge and availability of this relatively new class of disinfecting compounds, many efforts have been made to extend their commercial application. With each new mode of use, problems have arisen that have not always been solved with complete success. In fact, considerable research effort has been spent endeavoring to keep up with the many problems that have limited the practical usefulness of this class of compounds.

It is generally agreed that the unique properties of the quaternaries are:

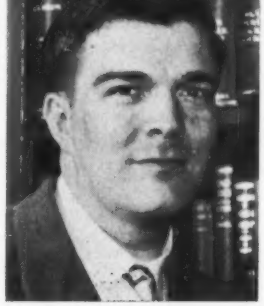
(1) Non-irritating to the skin,
(2) Relatively lesser susceptibility to the presence of organic matter as compared with chlorine, and
(3) Prolonged bacteriostatic action.

Because of these apparent advantages considerable attention has been directed towards the introduction of quaternaries for use as disinfectants and sanitizers of food-handling equipment. However, with extended use, other less advantageous properties were discovered. Thus it was found that quaternaries were:

(1) Adversely affected by hard waters [1, 2, 3, 4],
(2) Not as effective at lower temperatures [4, 5],
(3) Considerably affected by the pH of the solution [4, 6],
(4) Subject to a tendency to be adsorbed and removed from the solution by non-bacterial contaminations [7, 9],
(5) Dissimilar in their germicidal effect [4], and that there is
(6) No practical method for rapidly or easily determining the residual bactericidal potency of a use solution with accuracy [4, 5, 8, 16].

As a result of much work, therefore, there has come a realization that quaternaries are not a complete answer to all disinfection problems, but that with limitations, they may be capable of performing satisfactorily in certain fields under carefully controlled conditions [4, 5, 10].

The search for the square hole for the quaternary square peg is appearing to concentrate on their use as detergent "sanitizers" [11, 12, 13] and, in some ways, this development might have been regarded as inevitable. By detergent-sanitization [14] the proponents mean a combined detergent and disinfectant action that considerably reduces the bacterial population on a surface, but not necessarily effects a complete kill, it being claimed that this is sufficient for most practical uses in the food-handling field. This detergent-sanitization thus differs from the regular treatment that, for example, is practiced by the milk industry, that involves first a cleaning or detergent treatment which is followed by a chlorine disinfecting rinse which acts on the cleaned surfaces.



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The discoveries of the adverse properties of the quaternaries listed above were paralleled by the realization that the quaternaries were, in general, more effective in alkaline solutions [4, 17] and that the use of alkalies with quaternaries often made them less sensitive to the adverse effects of hard waters in which use solutions are prepared [18]. Alkalies have detergent properties and this combination, by necessity, of deter-

gents and disinfectants probably led to the idea that if such a combination has to be used, one might as well capitalize on it to the fullest extent. From this start to the production of as good a detergent-sanitizer as possible, was the next and natural development.

Detergent-sanitizers as such are not novel. They represent a time-saving idea, and their use, based on chlorine, has been attempted in the past. However, experience led to its discard because of the rapidity with which chlorine attacked organic matter as well as bacteria. This led to the too rapid exhaustion of the bactericide in the presence of contamination. It is because quaternaries appeared to be less susceptible to organic matter that this idea has been revived, it being thought that before the quaternary has exhausted itself on non-bacterial organic matter, a sufficient or practical drop in the bacterial population would have resulted.

The many effective types of quaternaries complicate a study considerably because of the many combinations that might be possible.

## NON-IONIC AGENTS

One aspect of the preparation of the "sanitizers" that has received very little published attention has been the introduction as an ingredient of the detergent-sanitizers the so-called non-ionic detergents. It is with this phase of the problem that we are most concerned with in this paper. These "non-ionics" have been added to obtain a twofold effect. They improve the detergent properties of the solutions, and because of a dispersing effect the precipitate that often forms when a quaternary alkali combination is added to hard water [5] is apparently lessened by the addition of a non-ionic. In some cases, a clear solution results, but which, on standing, develops a haze. Probably the non-ionic acts by reducing the particle size of the potential precipitate to the point where it can stay suspended in an invisible form or at least to the extent that it takes a longer period for it to coagulate to form a visible precipitate.

Quaternary disinfectants, though they are surface-active agents, do not have as good detergent action even when formulated with alkaline detergents as properly built soaps and such other anionics as the alkyl aryl sulfonate wetting agents. To compete on a detergent basis, therefore, the sanitizers require the incorporation of more effective detergents. Because of the complete incompatibility of the anionic agents due to the formation of inactive insoluble complexes, and the fact that combination with cationics of good detergent action appears to reduce the bactericidal effect [15], there has been only one apparent possibility and that is the incorporation of the so-called non-ionics. These latter all owe their detergency and wetting action to the combination of a large hydrophobic part of the molecule with a large hydrophilic part which is a polyether that has a high ratio of oxygen. There is usually at least one uncombined hydroxyl in the molecule. Such compounds are freely prepared by reacting such a product as ethylene oxide with any large molecule that contains at least one large hydrocarbon group and a reactive H atom. The ethylene oxide reacts with this latter forming a free hydroxyl, thereby producing another reactive H which can react with a further molecule of ethylene oxide. This process can be repeated *ad infinitum*. A whole range of non-ionics, from liquids to solids, can be produced depending on the extent of the reaction. Usually the non-ionics used in sanitizers are liquids, freely soluble in water, and are tailor-made by allowing the reaction to proceed to a predetermined point. Such starting materials for reaction with ethylene oxide are high molecular weight fatty acids, alkyl phenols, and higher alkyl mercaptans. These produce the main non-ionics, but others such as complex amides based on the condensation of fatty acids with alkanol amines are also encountered.

It has been generally stated in the various technical bulletins of the interested commercial organizations that non-ionics are compatible with quaternaries. To workers in our fields, this is interpreted to mean that there is no loss in germicidal efficiency by such a combination. As far as we could determine, there has been no published information as to this. We thought, particularly because of the unusual and often disappointing properties of the quaternaries, that we should not allow this to go unchecked.

## UNRELIABILITY FOUND

As a result of our work, we have found that there is really no truly non-ionic detergent, that all ionize to a certain degree, and more important, we have yet to find one that does not have a detrimental effect on the bactericidal power of a quaternary with which it is combined.

By judicious selection of quaternary non-ionic and inorganic alkali detergents, a compromise may be effected that has excellent detergent and disinfecting propertes. However, it is not the purpose of this paper to publicize any such product or combination. Our main object is the presentation of evidence to show the combination of quaternary and non-ionic is not foolproof, and that great care must be exercised in their selection. Proper tests must be made of each and every combination or else we may well find ourselves in the position of approving the combination of an outstandingly good disinfectant with an outstandingly good non-ionic detergent to end up with an outstandingly good detergent with none or practically no disinfecting power and thus result in a sanitizer that might well be no better than soap and water, its use being more dangerous in that we would rely on a protection that would not exist. To emphasize the public health importance of this, it might be well to list, from various advertising pamphlets, a few of the many operations where it is suggested that quaternary sanitizers or disinfectants might be employed.

(1) Sanitizing glassware in tap-rooms, restaurants, hotels and soda fountains.
(2) Disinfecting swimming pools, lavatories, and shower rooms.
(3) Sterilizing cow's udders prior to milking.
(4) Germicidal detergent in the dairy, brewery, and soft drink industries.
(5) Washing operating-room equipment.

The scope of these proposed uses speaks for itself.

Because of the innumerable combinations that would be possible to completely show this effect if all of the various alkalies were used along with the quaternary and non-ionics, we are going to standardize on one of them, sodium carbonate. In general, this provides sufficent alkalinity to offset the pH and hard water effects and is a common ingredient in many commercial "sanitzers". We have tested this in combination with a number of the well-known commercially available quaternaries and tested this combination with varying amounts of several of the commercially available non-ionics. Furthermore, we have made a series of similar tests on a smaller scale to show that the phenomenon is not a limited effect. The quaternaries and non-ionics used have been identified either by a chemical name or description rather than by proprietary names. Thus, for convenience:

| *Quaternary* | *Description* |
|---|---|
| A | Cetyl pyridinium chloride |
| B | Para t. octyl phenoxy ethoxy ethyl dimethyl benzyl ammonium chloride |
| C | Alkyl ($C_8$ to $C_{18}$ av. $C_{12}$) dimethyl benzyl ammonium chloride |
| D | Alkyl ($C_8$ to $C_{16}$) benzyl trimethyl ammonium chloride |
| E | Methyl dodecyl benzyl trimethyl ammonium chloride |
| F | Myristamido propyl dimethyl benzyl ammonium chloride |
| *Non-ionic* | |
| W | Polyoxy ethylene derivative of an octyl phenol |
| X | Polyoxy ethylene derivative of a dodecyl mercaptan |
| Y | Polyoxy ethylene derivative of stearic acid |
| Z | Alkanol amide of cocoanut oil fatty acids |

## EXPERIMENTAL FINDINGS

We have chosen, in our first series, to work entirely with a synthetic hard water of 400 ppm made up according to the specifications of the Quartermaster Department of the U. S. Army [19], since this would represent practical conditions for use far more than distilled water and is more reproducible than if we had used a natural hard water that not only varies all over the country, but which varies daily in a community.

We have used, throughout the work, a procedure modified from the original F. D. A. method of testing for phenol coefficients [20]. The test suspension consists of 100,000,000 organisms per ml of each of the following:

*Salmonella typhosa* (Hopkins strain)
*Escherichia coli* (University of Illinois Medical School)
*Micrococcus pyogenes* var. *aureus* (F. D. A. Strain)

The test organisms are grown on F. D. A. agar slants for 24 hours, the growth washed off with saline, and standardized by use of turbidity measurement in a Standard Junior Coleman Spectrophotometer. Five-tenths of 1 ml of this suspension is added to the 5 ml test solution which is kept at a constant temperature of 20° C in a water bath. Loopfuls of the test solution are taken at 5- and 10-minute intervals and subcultured in Difco nutrient broth. The tubes are incubated and examined after 48 hours, and notations made by asterisk or minus according as to whether growth is present or not. No inhibitor has been added to allow for bacteriostasis. However, the following methods have been used on a limited scale with similar results:

TABLE 1

EFFECT OF NON-IONIC W ON QUATERNARY A TESTED IN THE PRESENCE OF 400 PPM ARTIFICIAL HARD WATER AND 1700 PPM SODIUM CARBONATE

Non-ionic kept constant in concentrations indicated. F. D. A. method 5 and 10 minute interval transfer. Temperature 20° C.

| | *Parts per million Non-Ionic W* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *0* | | *200* | | *500* | | *1000* | |
| *Quaternary A* Parts per million | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* |
| 300 | .. | .. | .. | .. | .. | .. | — | — |
| 250 | .. | .. | .. | .. | — | — | — | — |
| 200 | .. | .. | .. | .. | — | — | * | — |
| 150 | .. | .. | .. | .. | — | — | * | * |
| 100 | — | — | — | — | * | — | * | * |
| 75 | — | — | — | — | * | * | .. | .. |
| 50 | — | — | — | — | .. | .. | .. | .. |
| 37.5 | — | — | * | — | .. | .. | .. | .. |
| 25 | * | — | * | * | .. | .. | .. | .. |

(1) Weber and Black Technique [21],
(2) Goetchius technique (Method presented at the 49th Annual Meeting of the Society of American Bacteriologists, Cincinnati, Ohio, 1949),
(3) F. D. A. technique incorporating Tamol N inhibitor according to the method of Goetchius [22].

The alkali and hard water were kept constant in all medication tubes at 1700 and 400 ppm respectively. The non-ionic was held constant in all tubes in amounts indicated, i.e., 0, 200, 500 and 1000 ppm. These concentrations have been selected since they approximate what would be obtained from a sanitizer containng about 10 per cent quaternary, about 80 per cent alkali builder, and 10 percent non-ionic which is added to hard water to give a final concentration of quaternary sufficient to effect a kill or be useful as a sanitizer. Such a combination might be considered typical of some commercial sanitizers. Thus, a pattern of conditions necessary to effect a kill is determined. From these readings a complete picture of the effect of the non-ionic on the quaternary is shown. Table 1 shows this effect of non-ionic W on Quaternary A.

From these results no other conclusion can be drawn other than that there is a decided effect of this non-ionic in reducing the effectiveness of the quaternary A. A similar series of results were obtained with other non-ionics and this quaternary, and with the non-ionics with all the other quaternaries tested. For clarity and conciseness these results are all summarized in table 2. Results are listed as the concentration of quaternary required to

TABLE 2

EFFECT OF FOUR NON-IONICS ON SIX QUATERNARIES TESTING IN THE PRESENCE OF 400 PPM ARTIFICIAL HARD WATER AND 1700 PPM SODIUM CARBONATE. F. D. A. METHOD. TEMPERATURE 20° C.

| | | *Parts per million quaternary required to effect a kill in 10 minutes but not in 5 minutes* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Quaternary A* | *Quaternary B* | *Quaternary C* | *Quaternary D* | *Quaternary E* | *Quaternary F* |
| Non-ionic W | ppm | | | | | | |
| | 0 | 25 | 50 | 25 | — | 75 | — |
| | 200 | 37.5 | 75 | 25 | 50 | 75 | 75 |
| | 500 | 100 | 100 | 37.5 | 75 | 150 | 150 |
| | 1000 | 200 | 250 | 75 | 150 | 200 | 300 |
| Non-ionic X | ppm | | | | | | |
| | 0 | 25 | 50 | 25 | — | 50 | — |
| | 200 | 25 | 50 | 25 | 37.5 | 75 | 50 |
| | 500 | 75 | 75 | 25 | 75 | 75 | 125 |
| | 1000 | 150 | 150 | 50 | 125 | 150 | 300 |
| Non-ionic Y | ppm | | | | | | |
| | 0 | 25 | 50 | 25 | — | — | — |
| | 200 | 37.5 | 100 | 37.5 | — | — | — |
| | 500 | 75 | 150 | 50 | — | — | — |
| | 1000 | 150 | 250 | 75 | — | — | — |
| Non-ionic Z | ppm | | | | | | |
| | 0 | 25 | 50 | 25 | — | 75 | — |
| | 200 | 75 | 100 | 37.5 | 50 | 75 | 100 |
| | 500 | 150 | 150 | 50 | 75 | 150 | 200 |
| | 1000 | 250 | 250 | 100 | 125 | 250 | 400 |

kill in 10 minutes, but not in 5 minutes, with fixed amounts of non-ionic and sodium carbonate. All other conditions were the same as listed above. We believe that this series, as shown in table 2, gives a very complete picture and shows that it is a general phenomenon with quaternaries and non-ionics that differ only in degree. It would appear that each non-ionic has a definite negative factor which varies with the quaternary with which it is compounded.

TABLE 2A

AMOUNT OF QUATERNARY INACTIVATED BY 400 PPM NON-IONIC

| | *Quaternary A* | *Quaternary B* | *Quaternary C* | *Quaternary F* |
|---|---|---|---|---|
| Non-ionic W | 80 ppm | 120 ppm | 30 ppm | 120 ppm |
| X | 60 ppm | 60 ppm | 20 ppm | 140 ppm |
| Y | 60 ppm | 80 ppm | 20 ppm | |
| Z | 80 ppm | 80 ppm | 40 ppm | 160 ppm |

To show this effect better, table 2A has been compiled by interpretation of table 2 to show the ppm of quaternary inactivated by 400 ppm of non-ionic since this would be a practical combination if a sanitizer were to be made up to give 200 ppm quaternary in solution and a concentration of non-ionic exactly double the quaternary were employed. (The extra ppm of quaternary to prove effective going from 500 ppm to 1000 ppm of non-ionic was multiplied by 4 and divided by 5 to give an extrapolated value for 400 ppm of non-ionic.)

Thus, if we used Quaternary F and Non-ionic Z in combination instead of having 200 ppm, we should have 40 ppm which might well lead to disaster.

Similarly Quaternary B with Non-ionic W would only leave 80 ppm of effective quaternary.

Furthermore, to show that this phenomenon is not particular to the use of sodium carbonate, we have run a similar short series (table 3) using tri sodium phosphate in place of soda ash. The same pattern is apparent.

Similarly in table 4 is shown a similar series in which no alkali is used, but just a mixture of quaternary and non-ionic. In this case, we have used distilled water instead of hard water to reduce the potential causes for such a phenomenon. Again in table 5, we have shown the use of soda ash, quaternary, and non-ionic in distilled water. In every case this negative factor of a non-ionic and quaternary is apparent.

In connection with this, it is interesting to note, and we present this as a coincidence since we are not sure as to its theoretical significance, that there is an extraordinary parallel between this negative factor of non-ionics towards quaternaries and a direct measurement of the degree of non-ionic character, namely, conductivity. If a substance is truly non-ionic, then we should expect no conductivity or infinite resistivity while a conductivity measurement would indicate the degree of ionization. We have found that, in general, the non-ionics that have the lowest negative factor have the lowest conductivity (highest resistance) and thus, are more truly non-ionic, while those that have the higher negative factor have correspondingly the greater conductivity (lower resistance). Table 6 shows some of our resistance measurements which can be compared with the negative factors previously shown. We ourselves have used this phenomenon to the extent of a tentative screening test when checking new non-ionics and have found it to be reliable in every case so far. We are not recommending its use at this time but we believe that it is of interest.

TABLE 3

EFFECT OF NON-IONICS ON QUATERNARY A TESTED IN THE PRESENCE OF 400 PPM HARD WATER AT 20° C. AND 1,700 PPM TRI SODIUM PHOSPHATE

Non-ionics kept constant at concentration indicated. F. D. A. method, 5 and 10 minute interval transfer.

*Parts per million Non-ionic W*

| *Quaternary A Parts per million* | *0* | | *200* | | *500* | | *1000* | |
|---|---|---|---|---|---|---|---|---|
| | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* |
| 300 | .. | .. | .. | .. | .. | .. | .. | .. |
| 250 | .. | .. | .. | .. | — | — | — | — |
| 200 | .. | .. | .. | .. | — | — | — | — |
| 150 | .. | .. | .. | .. | — | — | — | — |
| 100 | — | — | — | — | — | — | * | — |
| 75 | — | — | — | — | * | — | * | * |
| 50 | — | — | — | — | .. | .. | .. | .. |
| 37.5 | — | — | — | — | .. | .. | .. | .. |
| 25 | — | — | * | * | .. | .. | .. | .. |

*Parts per million Non-ionic Y*

| *Quaternary A Parts per million* | *0* | | *200* | | *500* | | *1000* | |
|---|---|---|---|---|---|---|---|---|
| | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* |
| 300 | .. | .. | .. | .. | .. | .. | .. | .. |
| 250 | .. | .. | .. | .. | — | — | — | — |
| 200 | .. | .. | .. | .. | — | — | — | — |
| 150 | .. | .. | .. | .. | — | — | * | — |
| 100 | — | — | — | — | * | — | * | — |
| 75 | — | — | — | — | * | — | * | * |
| 50 | — | — | * | * | .. | .. | .. | .. |
| 37.5 | — | — | * | — | .. | .. | .. | .. |
| 25 | — | — | * | * | .. | .. | .. | .. |

## CONCLUSIONS

Non-ionic detergents have a definite negative or neutralizing effect on the germicidal power of quaternaries. Their use together, though possible and practical, must be examined closely and tests made on every suggested formulation to ensure that this negative factor has not eliminated the usefulness of the quaternary as a bactericide.

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TABLE 4

EFFECT OF QUATERNARY AND NON-IONIC IN PRESENCE OF DISTILLED WATER WITH NO ALKALI PRESENT

All other conditions as in Table 2.

*Parts per million Non-ionic W*

| *Quaternary A Parts per million* | *0* | | *200* | | *500* | | *1000* | |
|---|---|---|---|---|---|---|---|---|
| | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* |
| 200 | — | .. | .. | .. | .. | .. | — | — |
| 150 | .. | .. | .. | .. | — | — | — | — |
| 100 | .. | .. | .. | .. | — | — | * | * |
| 75 | .. | .. | .. | .. | — | — | * | * |
| 50 | — | — | — | — | * | * | * | * |
| 37.5 | — | — | — | — | * | * | .. | .. |
| 25 | — | — | * | — | .. | .. | .. | .. |
| 10 | * | * | * | * | .. | .. | .. | .. |
| 5 | * | * | * | * | .. | .. | .. | .. |

*Parts per million Non-ionic Y*

| *Quaternary A Parts per million* | *0* | | *200* | | *500* | | *1000* | |
|---|---|---|---|---|---|---|---|---|
| | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* |
| 200 | .. | .. | .. | .. | .. | .. | — | — |
| 150 | .. | .. | .. | .. | — | — | — | — |
| 100 | .. | .. | .. | .. | — | — | * | * |
| 75 | .. | .. | .. | .. | * | * | * | * |
| 50 | — | — | — | — | * | * | * | * |
| 37.5 | — | — | — | — | * | * | .. | .. |
| 25 | — | — | * | * | .. | .. | .. | .. |
| 10 | * | * | * | * | .. | .. | .. | .. |
| 5 | * | * | * | * | .. | .. | .. | .. |

TABLE 5

EFFECT OF QUATERNARY, NON-IONIC, AND $Na_2CO_3$ IN DISTILLED WATER IN PLACE OF HARD WATER

All other conditions as shown in Table 2.

*Parts per million Non-ionic W*

| *Quaternary A Parts per million* | *0* | | *200* | | *500* | | *1000* | |
|---|---|---|---|---|---|---|---|---|
| | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* |
| 200 | .. | .. | .. | .. | .. | .. | — | — |
| 150 | .. | .. | .. | .. | — | — | — | — |
| 100 | .. | .. | .. | .. | — | — | * | * |
| 75 | .. | .. | — | — | * | — | * | * |
| 50 | — | — | — | — | * | — | * | * |
| 37.5 | — | — | — | — | * | * | .. | .. |
| 25 | — | — | * | — | .. | .. | .. | .. |
| 10 | * | — | * | * | .. | .. | .. | .. |
| 5 | * | * | .. | .. | .. | .. | .. | .. |

*Parts per million Non-ionic X*

| *Quaternary A Parts per million* | *0* | | *200* | | *500* | | *1000* | |
|---|---|---|---|---|---|---|---|---|
| | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* | *5 min.* | *10 min.* |
| 200 | .. | .. | .. | .. | .. | .. | — | — |
| 150 | .. | .. | .. | .. | — | — | — | — |
| 100 | .. | .. | .. | .. | — | — | * | * |
| 75 | .. | .. | — | — | — | — | * | * |
| 50 | — | — | — | — | * | * | * | * |
| 37.5 | — | — | — | — | * | * | .. | .. |
| 25 | — | — | * | * | .. | .. | .. | .. |
| 10 | * | — | * | * | .. | .. | .. | .. |
| 5 | * | * | .. | .. | .. | .. | .. | .. |

TABLE 6

RESISTANCE MEASUREMENTS OF VARIOUS NON-IONICS

| | *Specific resistance in ohms* |
|---|---|
| Triple distilled water | 410,000 ohms |
| With 0.1% non-ionic W | 106,000 " |
| " 0.5% " W | 31,500 " |
| " 0.1% " X | 365,000 " |
| " 0.5% " X | 270,000 " |
| " 0.1% " Z | 45,000 " |
| " 0.5% " Z | 15,000 " |


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# THE EXPANSION OF THE CREAM VOLUME OF FLUID MILK BY THE ADDITION OF SUPERHEATED CONDENSED MILK AND ITS DETECTION[1]

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MOST MILK plant operators endeavor to preserve the creaming ability of their pasteurized bottled milk by careful control of the practices and processes which are known to limit cream volume. Some milk dealers, however, are continually on the lookout for ways and means of expanding the cream volume of their product in order to obtain a selling advantage over their competitors. Recently, evidence has come to the attention of regulatory officials that a number of milk processors in the northeastern area have been increasing the cream volume of bottled milk by the generally illegal practice of standardizing milk of relatively high fat content to lower levels by additions of reconstituted superheated condensed skim milk. Unfortunately, the authorities have been unable to cope satisfactorily with the practice because no sufficiently accurate methods for detecting this type of adulteration, in the proportions employed, are available.

There is no information in the literature relative to the effect of additions of heat-thickened protein on the creaming ability of fluid milk and no reported observations relative to the characteristics of such treated milk. In view of this situation, a study was made of the limiting factors involved in this phenomenon and to investigate possible ways of detecting the adulterations by methods readily employable by public health laboratories.

## PROCEDURES AND METHODS

As a source of superheated condensed milk, good quality, mixed, skim milk or whole milk was concentrated, by conventional methods, in a batch vacuum pan and standardized to 30 percent total solids or 12 percent fat, respectively. Superheating was accomplished by controlled heating of liter quantities of the concentrate in large Erlenmeyer flasks in a water bath at 180° F, the desired thickening (viscosity) being obtained by varying the time of treatment. The superheated product was then cooled and held under refrigeration. Viscosity readings were made after 24 hours utilizing a Borden Flow Meter (minus tip) and after sample had been tempered at 68° F for one hour. All samples were classified as light, medium, and heavy in viscosity on an arbitrary basis. When added to fluid milk for noting the effect on creaming ability, all portions of superheated condensed skim milk were carefully reconstituted (with water) to the fluid state based on the analysis before concentrating while superheated condensed whole milk was reconstituted to the fat content of the milk to which it was added.

Fluid whole milk, whose creaming properties on adulteration were to be studied, consisted of samples of mixed milk from about 55 different herds used singly and also in combination. Various proportions of the superheated products were added and for control purposes equal quantities of solids were added to similar samples in the form of fluid skim milk or whole milk. In all cases, the additions were made before pasteurization at 144° F for 30 minutes using laboratory facilities for the process.

Samples for cream volume measurement were taken immediately after cooling, placed in 100-ml cylinders, and introduced into an ice-water bath in a room varying in temperature between 35° and 40° F. Readings were made after 24 hours and expressed as percent of cream volume on the basis of the entire volume of the sample. Increases in cream volume due to additions of heat-thickened protein were based on the increase in percent of cream volume as compared to control samples containing the same quantity of added solids in the form of normal fluid skim milk or whole milk. Portions of the samples were allowed to cream in milk bottles for the studies dealing with methods of detection.

Where it was desired to separate the cream layers from the under layers for the purpose of analysis or to make other observations, a water aspirator pump connected through a collecting flask to a long, small diameter, glass tube was employed. The tube was carefully inserted into the quart sample (with the top closed) until the tip reached the bottom. By suction the under layer was then drawn off carefully and slowly into the collecting flask leaving the cream layer in the bottle. The bottle was carefully tipped to obtain as clean a separation as possible.

Sediment was determined by centrifuging 50 ml of the mixed sample in a 50-ml tapered centrifuge tube for 30 minutes at 2500 rpm. The result was expressed as volume percent.

The viscosity of the under layers of creamed samples was determined by an Ostwald viscosimeter of small bore in a constant temperature bath at 68° F. The flow time for water was 82.7 seconds.

Protein analyses were made by the Kjeldahl method of Rowland [1, 2] except in the large number of cases where the fat/casein ratio of the cream layer was sought. Here casein was determined by the rapid method of Walker.[3]

## RESULTS

### Effect of Additions of Superheated Condensed Milk to Normal Milk on the Creaming Phenomenon

The results obtained in the first portion of the study demonstrate that reconstituted superheated condensed skim milk or whole milk when added to fluid milk increases the cream volume strikingly over what it would be in normal milk of comparable fat content or in the same milk to which comparable quantities of fluid skim milk or fluid whole milk are added. Normal herd milk samples were treated with increasing amounts of reconstituted superheated condensed skim milk and similar whole milk and it was found

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that cream volume increases ranged from zero up to 200 percent compared with control samples. In cases where the cream volume increase was 150 percent or more, it was noted that the cream line demarcation was indistinct and the layer not prominent. Typical results obtained in two trials are presented in tables 1 and 2.

The degree of expansion of the cream layer caused by superheated condensed milk is dependent primarily on the proportion of the adulterant added. This proportion is perhaps best expressed quantitatively as a ratio between the amount of heat-thickened protein and the amount of fat. If this ratio is plotted against the cream volume increase it is found, almost invariably, that the maximum increase is obtained when the heat-thickened protein/fat ratio is between 0.20 and 0.35. This is shown for one trial, out of several made, in the accompanying graph.

TABLE 1

EFFECT OF ADDITIONS OF RECONSTITUTED SUPERHEATED CONDENSED SKIM MILK ON CREAM VOLUME AND ON FAT TO S.N.F. AND FAT TO CASEIN RATIOS OF THE CREAM LAYER OF MILK TO WHICH IT IS ADDED

(Typical Trial)

| | | | Cream Volume | | | Cream Layer | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Milk sample | Fat | Addition | 24 hours | Increase | Per 1 percent fat | Fat | Casein | Snf | Fat/Snf | Fat/casein |
| | % | % | % | % | % | % | % | % | | |
| Normal milk | 4.8 | ... | 16.0 | ... | 3.3 | 27.80 | 2.00 | 6.82 | 4.08 | 13.90 |
| Milk+skim milk | 4.6 | 4.3 | 15.5 | ... | 3.4 | .... | .... | .... | .... | .... |
| Milk+skim milk | 4.4 | 8.3 | 15.0 | ... | 3.4 | .... | .... | .... | .... | .... |
| Milk+skim milk | 4.2 | 12.5 | 14.0 | ... | 3.3 | .... | .... | .... | .... | .... |
| Milk+R.S.C.S.* | 4.6 | 4.3 | 20.0 | 29 | 4.3 | 20.67 | 2.23 | 7.54 | 2.74 | 9.27 |
| Milk+R.S.C.S. | 4.4 | 8.3 | 24.0 | 60 | 5.5 | 16.17 | 2.35 | 8.13 | 1.99 | 6.88 |
| Milk+R.S.C.S. | 4.2 | 12.5 | 28.0 | 100 | 6.7 | 13.29 | 2.48 | 8.35 | 1.59 | 5.36 |

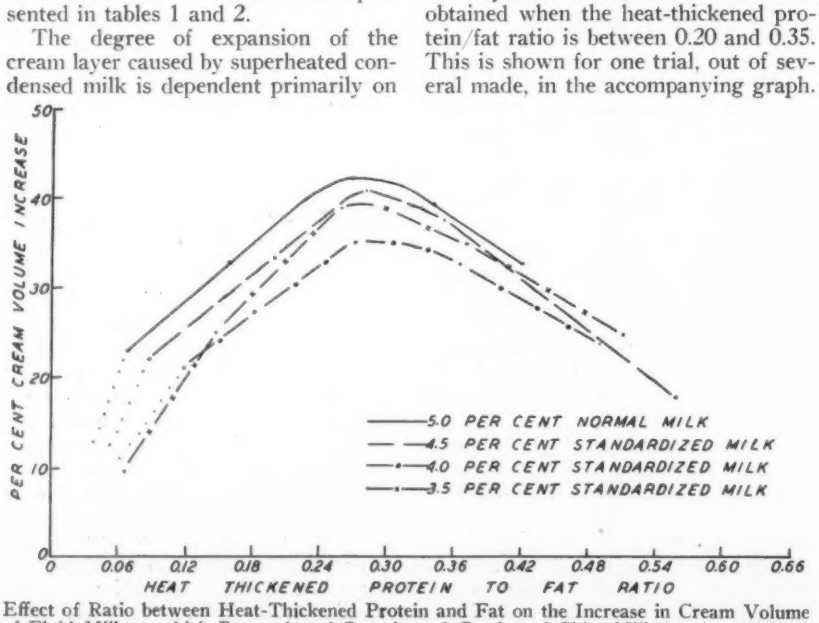
* Reconstituted superheated condensed skim milk with "heavy" viscosity.
Snf = Solids not fat.

TABLE 2

EFFECT OF ADDITIONS OF RECONSTITUTED SUPERHEATED CONDENSED WHOLE MILK ON CREAM VOLUME AND ON FAT TO S.N.F. AND FAT TO CASEIN RATIOS OF THE CREAM LAYER OF MILK TO WHICH IT IS ADDED

| | | | Cream Volume | | | Cream Layer | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk sample | Fat | Addition | 24 hours | Increase | Per 1 percent fat | Fat | Casein | Snf | Fat/Snf | Fat/casein | Sediment |
| | % | % | % | % | % | % | % | % | | | % |
| Normal milk | 4.0 | .. | 12.0 | .. | 3.0 | 26.84 | 2.00 | 7.08 | 3.79 | 13.42 | 0.6 |
| Milk+R.S.C.M.* | 4.0 | 5 | 17.0 | 42 | 4.3 | 18.33 | 2.38 | 7.98 | 2.30 | 7.70 | 0.8 |
| Milk+R.S.C.M. | 4.0 | 10 | 23.0 | 92 | 5.8 | 13.34 | 2.48 | 8.52 | 1.57 | 5.38 | 1.4 |
| Milk+R.S.C.M. | 4.0 | 15 | 29.0 | 142 | 7.3 | 10.62 | 2.64 | 8.73 | 1.22 | 4.02 | 2.8 |

* Reconstituted superheated condensed whole milk with "heavy" viscosity.




Effect of Ratio between Heat-Thickened Protein and Fat on the Increase in Cream Volume of Fluid Milk to which Reconstituted Superheated Condensed Skim Milk has been Added.

The maximum increase in cream volume obtainable will vary with different lots of milk and particularly with different degrees of superheating of the adulterant but it nevertheless occurs in the vicinity of 0.30 part of superheated protein to one of fat.

The influence of the degree of superheating of the adulterant is illustrated by the data in table 3 where this degree is indicated by the time of treatment at 180° F and also by the resulting viscosity. A highly thickened product causes considerably greater expansion of the cream layer than does a less thickened one.

## Causes of Expanded Cream Layer

The increase in cream volume of fluid milk to which reconstituted superheated condensed skim milk or whole milk is added is due to the fine protein floccules present in the heat-thickened adulterant and which are responsible for the high viscosity or heavy body of the latter. A considerable quantity of these minute protein aggregates apparently become enmeshed in the rising fat globule clusters and are carried into the cream layer. These conclusions are based upon four supporting observations. First, homogenization of the superheated product which destroys the viscosity by disintegrating the floccules also destroys the ability of the superheated milk to increase the cream layer of fluid milk. Second, centrifuged adulterated samples of milk show higher than normal amounts of sedimentation and the amount increases with the percentage of adulteration, table 2. Third, the degree of expansion of the cream layer is increased as the viscosity of the adulterant is increased, table 3. Fourth, the cream layers of adulterated samples contain more than normal quantities of protein and the discrepancy becomes wider with increasing amounts of the adulterant, table 4. Some other factors may also play a role in the phenomenon. It was observed, for instance, that the rate of creaming of adulterated samples is slower than normal. This might be expected from the increase in viscosity of the medium, table 5, and the anticipated increase in density of the fat globule clusters containing the protein floccules.

## Methods for Detecting the Adulteration

Positive detection of the adulteration of milk with superheated condensed

TABLE 3

EFFECT OF THE DEGREE OF SUPERHEATING OF CONDENSED SKIM MILK ON THE CREAM VOLUME OF NORMAL MILK TO WHICH IT IS ADDED

| Milk sample | Degree of superheating | Viscosity superheated product | Fat | Addition | Cream Volume | | |
|---|---|---|---|---|---|---|---|
| | | | | | 24 hours | Increase | Per 1 percent fat |
| | Min. at 180° F. | Seconds | % | % | % | % | % |
| Normal milk | .. | ... | 3.6 | .. | 12.5 | ... | 3.5 |
| Milk+skim milk | .. | ... | 3.1 | 14 | 10.0 | ... | 3.2 |
| Milk+RSCS* | 0 | 51.5 | 3.1 | 14 | 15.0 | 50 | 4.8 |
| Milk+RSCS | 5 | 103.6 | 3.1 | 14 | 17.0 | 70 | 5.5 |
| Milk+RSCS | 10 | 246.4 | 3.1 | 14 | 18.5 | 85 | 6.0 |
| Milk+RSCS | 15 | ** | 3.1 | 14 | 22.0 | 120 | 7.1 |
| Milk+RSCS | 20 | ** | 3.1 | 14 | 27.0 | 170 | 8.7 |

* Reconstituted superheated condensed skim milk.
** Too viscous to read.

milk is not easy if the adulterant is carefully reconstituted prior to use. So little need be employed to obtain the desired result that ordinary methods for detecting additions of skim milk are not sufficiently sensitive, and if whole milk superheated products are used these methods naturally would not be applicable at all.

Carefully adulterated milk exhibits normal appearance, flavor, alcohol number, freezing point, surface tension, and tyrosine values.[4] The nitroprusside test for "sulfide" groups[5] and the Evenson test for "bound" lactose,[6] are negative for milks adulterated to the extent of 5 to 15 percent. The superheated product itself, however, gives positive results for "sulfide" groups and "bound" lactose. Apparently the heat treatment used in superheating the condensed product is not sufficiently high to overcome the dilution effect and thus produce positive tests in the adulterated milk.

Microscopic techniques applied to the mixed milk and to the cream layers, with and without staining procedures, reveal no distinguishing criteria for the presence of heat produced protein floccules. The curd content of butter churned from the cream layers is normal, but occasionally the risen cream exhibits feathering tendencies in hot coffee.

*Sedimentation.* Adulterated milk, as indicated in table 2, shows more sediment on centrifuging than normal milk, but the amount will vary with the temperature, speed, and time of centrifuging as well as with the leucocyte count of different milks. Such variations limit the use of this measurement as a positive means of detecting the adulteration. Nevertheless, since most milk processors clarify their product and this tends to minimize the variation in sediment between different milks, excessive sediment (over one percent) may be considered as supporting evidence of adulterations of this kind.

TABLE 4

EFFECT OF ADDITIONS OF RECONSTITUTED SUPERHEATED CONDENSED SKIM MILK ON CREAM VOLUME OF FLUID MILK AND ON THE RATIOS OF FAT TO S.N.F., FAT TO CASEIN, AND CASEIN TO ALBUMIN-GLOBULIN IN THE CREAM LAYER FORMING ON SUCH MILK

| Milk sample | Fat | Addition | Cream Volume | | | Cream Layer | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 24 hours | Increase | Per 1 percent fat | Fat | Snf | Casein | Fat/ Snf ratio | Fat/ casein ratio | Protein | Albumin-globulin | Casein/ albumin-globulin ratio |
| | % | % | % | % | % | % | % | % | | | % | % | |
| Normal milk | 4.0 | .. | 13.0 | .. | 3.3 | 26.0 | 7.06 | 1.92 | 3.68 | 13.54 | 2.23 | 0.28 | 6.86 |
| Milk+skim | 3.5 | 13 | 11.0 | .. | 3.1 | 25.5 | 7.09 | 1.95 | 3.60 | 13.08 | 2.28 | 0.28 | 6.96 |
| Milk+skim | 3.0 | 25 | 10.0 | .. | 3.3 | 25.0 | 7.12 | 1.97 | 3.51 | 12.69 | 2.30 | 0.28 | 7.04 |
| Milk+skim | 2.5 | 38 | 8.0 | .. | 3.2 | 24.0 | 7.14 | 1.98 | 3.36 | 12.12 | 2.32 | 0.28 | 7.07 |
| Milk+RSCS* | 3.5 | 13 | 13.0 | 18 | 3.7 | 20.5 | 7.64 | 2.07 | 2.68 | 9.90 | 2.43 | 0.27 | 7.67 |
| Milk+RSCS | 3.0 | 25 | 12.5 | 25 | 4.2 | 17.0 | 7.43 | 2.22 | 2.29 | 7.66 | 2.56 | 0.26 | 8.54 |
| Milk+RSCS | 2.5 | 38 | 10.0 | 25 | 4.0 | 15.0 | 7.65 | 2.33 | 1.95 | 6.44 | 2.66 | 0.24 | 9.71 |

* Reconstituted superheated condensed skim milk with "heavy" viscosity.

TABLE 5

VISCOSITY OF THE UNDER LAYERS AND OF MIXED NORMAL AND ADULTERATED MILKS

| Milk sample | Fat | Addition | Cream Volume | | | Viscosity of mixed milk | Viscosity of under layer |
|---|---|---|---|---|---|---|---|
| | | | 24 hours | Increase | Per 1 percent fat | | |
| | % | % | % | % | % | seconds** | seconds** |
| Normal milk | 5.5 | .. | 17.0 | ... | 3.1 | 176.9 | 154.1 |
| Milk+skim | 5.0 | 9 | 15.0 | ... | 3.0 | 167.1 | 151.3 |
| Milk+skim | 4.5 | 18 | 13.5 | ... | 3.0 | 165.9 | 149.3 |
| Milk+skim | 4.0 | 27 | 13.0 | ... | 3.3 | 159.8 | 145.3 |
| Milk+skim | 3.5 | 36 | 11.0 | ... | 3.1 | 155.5 | 144.7 |
| Milk+skim | 3.0 | 45 | 10.0 | ... | 3.3 | 152.6 | 143.2 |
| Milk+RSCS* | 5.0 | 9 | 23.0 | 53 | 4.6 | 190.9 | 157.3 |
| Milk+RSCS | 4.5 | 18 | 27.0 | 100 | 6.0 | 197.0 | 165.2 |
| Milk+RSCS | 4.0 | 27 | 27.5 | 112 | 6.9 | 206.2 | 178.0 |
| Milk+RSCS | 3.5 | 36 | 27.0 | 145 | 7.7 | 214.6 | 187.3 |
| Milk+RSCS | 3.0 | 45 | 22.0 | 120 | 7.3 | 219.5 | 199.9 |

* Reconstituted superheated condensed skim milk with "heavy" viscosity.
** Using Ostwald pipette.

*Casein to Albumin and Globulin Ratio.* Superheating condensed milk causes a partial heat denaturation and coagulation of the protein phase including casein and results in the whey proteins (albumin and globulin) being included as casein in conventional protein determinations by Kjeldahl methods. Hence, higher casein to albumin-globulin ratios are found in the cream layers of adulterated milk as may be seen in table 4. Similar results, not reported here, are also found in the analysis of the mixed adulterated milks. Determinations of this type, however, are time consuming and many laboratories are not equipped to make them.

*Viscosity of Under Layer and Mixed Milk.* Mixed milk and the under layer of creamed milk, adulterated with superheated condensed milk, is higher than normal in viscosity when measured by an Ostwald pipette of small bore, table 5. Less sensitive viscosity instruments such as the Borden Flow Meter, and Brookfield Syncro-Electric Viscosimeter do not reveal significant differences. The increased viscosity of the adulterated samples is significant, of course, but the method was not considered one which most laboratories would be prepared to use.

*Fat to Casein and Fat to Solids-Not-Fat Ratios of the Cream Layer.* The cream layer of milk adulterated with superheated products exhibits lower than normal fat to casein and fat to solids-not-fat ratios. Typical data on these values may be noted in tables 1, 2, and 4. Excessive decreases in the fat content and increases in the solids-not-fat and casein content are noted in the cream layers of the adulterated samples with correspondingly significant decreases in the fat to solids-not-fat and fat to casein ratios as compared to these values in normal cream layers. Determinations of fat, solids-not-fat, and casein are relatively simple to make, inasmuch as the Babcock method, the Mojonnier or Official procedures, and the Walker method[3] respectively can be employed.

*Suggested Method for Detecting the Adulteration.* The fat to solids-not-fat and the fat to casein ratios of the cream layer appear to be the most conveniently obtained of the significant criteria for the detection of adulterations of normal milk with superheated condensed milk. Even a simple Babcock fat test of the cream layer is highly indicative provided the low fat content cannot be accounted for in any other way.

The fat to solids-not-fat ratios of the cream layers of 52 different normal pasteurized herd milks, tables 6 and 7, varied from 3.11 to 5.67 with an average of 3.78. Fat to casein ratios of the normal samples varied from 10.18 to 16.32 with an average of 13.34. As may be seen, similar ratios obtained for the cream layers of adulterated and subsequently pasteurized milks seldom approach the lowest values obtained for normal cream layers. Therefore, any values lower than 3.00 for fat to solids-not-fat and less than 10.00 for fat to casein are indicative of the adulteration in question.

(Continued on page 45)

TABLE 6

EFFECT OF ADDITIONS OF RECONSTITUTED SUPERHEATED CONDENSED SKIM MILK ON THE FAT TO SOLIDS-NOT-FAT AND FAT TO CASEIN RATIOS OF THE CREAM LAYER OF VARIOUS HERD MILKS TO WHICH IT IS ADDED

| Herd number | Fat % | Fat/Snf of cream layer | | | | Fat/Casein of cream layer | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Normal milk | Adulterated milk | | | Normal milk | Adulterated milk | | |
| | | | Slight | Medium | Large | | Slight | Medium | Large |
| 34 | 5.9 | 3.40 | 2.42 | 2.02 | 1.62 | 11.72 | 7.74 | 6.63 | 5.14 |
| 30 | 5.7 | 3.41 | 2.54 | 2.23 | 1.83 | 12.68 | 8.53 | 6.94 | 5.82 |
| 58 | 5.5 | 3.71 | 2.45 | 1.86 | 1.51 | 11.75 | 7.47 | 6.11 | 4.78 |
| 51 | 5.3 | 3.76 | 2.47 | 1.89 | 1.49 | 12.78 | 8.63 | 6.33 | 4.95 |
| 3 | 5.1 | 4.04 | 2.76 | 2.19 | 1.78 | 12.87 | 8.38 | 6.58 | 5.49 |
| 21 | 4.8 | 3.59 | 3.05 | 2.53 | 2.07 | 12.87 | 9.86 | 8.54 | 6.98 |
| 44 | 4.8 | 3.49 | 2.77 | 2.37 | 2.02 | 10.81 | 8.53 | 7.23 | 6.21 |
| 49 | 4.8 | 4.08 | 2.74 | 1.99 | 1.59 | 13.90 | 9.27 | 6.88 | 5.36 |
| 31 | 4.6 | 4.22 | 2.13 | 1.62 | 1.29 | 13.81 | 7.46 | 5.62 | 4.39 |
| 56 | 4.4 | 3.25 | 2.41 | 1.89 | 1.55 | 10.95 | 8.24 | 6.69 | 5.61 |
| 14 | 4.3 | 4.31 | 2.59 | 1.93 | 1.52 | 16.32 | 9.07 | 6.49 | 5.24 |
| 18 | 4.3 | 3.66 | 2.91 | 2.39 | 2.20 | 12.96 | 9.41 | 8.02 | 6.87 |
| 7 | 4.1 | 4.06 | 3.06 | 2.96 | 2.47 | 13.43 | 9.83 | 9.37 | 7.88 |
| 20 | 4.1 | 5.23 | 2.70 | 2.06 | 1.65 | 14.49 | 7.72 | 6.21 | 5.33 |
| 54 | 4.1 | 3.84 | 2.87 | 2.66 | 2.18 | 13.85 | 10.52 | 9.78 | 7.94 |
| 33 | 4.0 | 3.50 | 2.60 | 2.19 | 1.76 | 13.45 | 9.64 | 8.08 | 6.47 |
| 37 | 4.0 | 3.50 | 2.77 | 2.24 | 1.89 | 13.34 | 10.04 | 8.22 | 7.09 |
| 16 | 3.9 | 4.22 | 2.45 | 1.76 | 1.32 | 14.63 | 8.44 | 5.80 | 4.38 |
| 47 | 3.9 | 3.89 | 2.57 | 2.15 | 1.86 | 13.39 | 8.72 | 7.12 | 6.21 |
| 1 | 3.8 | 4.02 | 2.05 | 1.51 | 1.11 | 14.32 | 7.00 | 4.97 | 3.69 |
| 9 | 3.8 | 3.38 | 2.49 | 2.05 | 1.66 | 11.78 | 8.19 | 6.71 | 5.51 |
| 17 | 3.8 | 3.69 | 2.64 | 2.16 | 1.92 | 13.34 | 9.44 | 7.51 | 6.51 |
| 42 | 3.8 | 3.67 | 3.05 | 2.37 | 2.16 | 12.65 | 10.25 | 7.90 | 7.51 |
| 53 | 3.8 | 3.23 | 2.19 | 1.67 | 1.39 | 10.18 | 6.95 | 5.35 | 4.41 |
| 4 | 3.6 | 4.34 | 2.71 | 2.03 | 1.69 | 14.43 | 9.71 | 7.48 | 6.38 |
| 5 | 3.6 | 3.91 | 2.58 | 2.14 | 1.85 | 13.12 | 8.39 | 7.28 | 6.18 |
| 22 | 3.6 | 3.75 | 3.26 | 2.88 | 2.62 | 12.07 | 10.80 | 9.77 | 8.66 |
| 28 | 3.6 | 4.16 | 2.38 | 1.95 | 1.66 | 14.40 | 8.39 | 6.64 | 5.73 |
| 10 | 3.5 | 4.16 | 3.00 | 2.30 | 2.02 | 14.51 | 10.51 | 8.18 | 7.15 |
| 12 | 3.5 | 3.46 | 2.69 | 2.31 | 1.93 | 11.72 | 9.03 | 7.52 | 6.44 |
| 8 | 3.4 | 3.55 | 2.55 | 2.17 | 1.78 | 15.73 | 10.17 | 8.56 | 7.20 |
| 25 | 3.4 | 3.59 | 2.62 | 2.12 | 1.86 | 13.45 | 9.54 | 7.71 | 6.77 |
| 19 | 3.2 | 3.49 | 2.67 | 2.28 | 1.88 | 11.97 | 8.99 | 7.53 | 6.27 |
| 36 | 3.2 | 4.02 | 3.02 | 2.61 | 2.33 | 13.44 | 10.17 | 8.48 | 7.48 |
| 11 | 3.1 | 3.92 | 2.62 | 2.11 | 2.20 | 14.41 | 9.68 | 7.89 | 7.67 |
| 57 | 3.0 | 3.67 | 2.60 | 1.89 | 1.60 | 14.56 | 9.02 | 6.85 | 5.76 |
| Variation | | 3.23–5.23 | 2.13–3.06 | 1.51–2.96 | 1.11–2.47 | 10.18–16.32 | 6.95–10.80 | 4.97–9.78 | 3.69–8.66 |
| Average | | 3.81 | 2.60 | 2.25 | 1.81 | 13.22 | 9.00 | 7.33 | 6.15 |

TABLE 7

EFFECT OF ADDITIONS OF RECONSTITUTED SUPERHEATED CONDENSED WHOLE MILK ON THE FAT TO SOLIDS-NOT-FAT AND FAT TO CASEIN RATIOS OF THE CREAM LAYER OF VARIOUS HERD MILKS TO WHICH IT IS ADDED

| Herd number | Fat % | Fat/Snf of cream layer | | | | Fat/Casein of cream layer | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Normal milk | Adulterated milk | | | Normal milk | Adulterated milk | | |
| | | | 5% | 10% | 15% | | 5% | 10% | 15% |
| 49 | 5.7 | 3.11 | 1.99 | 1.54 | 1.23 | 11.07 | 6.20 | 4.99 | 4.03 |
| 30 | 5.1 | 3.76 | 2.17 | 1.58 | 1.18 | 14.18 | 7.67 | 5.53 | 3.83 |
| 51 | 5.0 | 3.42 | 2.03 | 1.61 | 1.37 | 12.50 | 7.27 | 5.42 | 4.63 |
| 21 | 4.4 | 3.59 | 2.12 | 1.66 | 1.23 | 13.97 | 7.51 | 5.69 | 4.40 |
| 54 | 4.2 | 3.59 | 2.32 | 1.77 | 1.48 | 14.36 | 8.44 | 6.53 | 4.96 |
| 25 | 4.1 | 5.67 | 1.82 | 1.25 | 1.73 | 12.88 | 7.11 | 4.80 | 5.09 |
| 32 | 4.0 | 3.64 | 2.28 | 1.72 | 1.46 | 14.31 | 8.76 | 6.53 | 5.32 |
| 33 | 4.0 | 3.79 | 2.30 | 1.57 | 1.22 | 13.42 | 7.70 | 5.38 | 4.02 |
| 35 | 4.0 | 3.20 | 2.21 | 1.73 | 1.41 | 12.37 | 7.65 | 6.13 | 4.98 |
| 19 | 3.9 | 3.79 | 2.82 | 2.13 | 1.68 | 14.38 | 8.78 | 7.04 | 5.83 |
| 42 | 3.9 | 3.35 | 2.12 | 1.59 | 1.30 | 12.71 | 7.60 | 5.71 | 4.37 |
| 18 | 3.8 | 3.81 | 2.10 | 1.56 | 1.29 | 15.06 | 7.41 | 5.22 | 4.30 |
| 12 | 3.7 | 3.48 | 2.38 | 1.89 | 1.63 | 13.41 | 8.69 | 6.75 | 5.89 |
| 20 | 3.6 | 3.50 | 2.08 | 1.49 | 1.19 | 14.78 | 8.12 | 5.20 | 4.23 |
| 15 | 3.5 | 4.13 | 2.55 | 1.73 | 1.44 | 15.55 | 9.74 | 6.43 | 5.17 |
| 7 | 3.4 | 3.32 | 2.41 | 1.90 | 1.56 | 12.63 | 8.63 | 5.81 | 4.90 |
| Variation | | 3.11–5.67 | 1.82–2.82 | 1.25–2.13 | 1.18–1.73 | 11.07–15.55 | 6.20–9.74 | 4.80–7.04 | 3.83–5.89 |
| Average | | 3.70 | 2.23 | 1.68 | 1.40 | 13.60 | 7.96 | 5.89 | 4.75 |

# A STUDY OF RESAZURIN REDUCTION IN FRESHLY DRAWN MASTITIC-LIKE MILK [1, 2]

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## INTRODUCTION

MASTITIS is an inflammation of the mammary gland. It is generally believed to be caused by bacterial infection, by injury to the teat or udder tissue, or both of these factors. The physical symptoms consist of glandular abnormalities, including inflammation, swelling, and tenderness; and visible abnormalities of the milk, including clots, viscous serum, and even blood. These are dependable criteria in the detection of acute infections and advanced cases of chronic mastitis, but they do not provide accurate means of diagnosis either of the early stages of infections or of the specific infecting agent.

Detailed diagnosis requires the examination and analysis of milk from the individual quarters of the udder. The presence of incriminating bacteria in the fore-milk is the primary indication of infectious mastitis. This condition, accompanied by large numbers of leucocytes, high concentrations of chlorides, and increases in catalase and pH values, is an indication of an established infection.

The resazurin test was included in the ninth edition of *Standard Methods for the Examination of Dairy Products* as an official technique for the grading of raw milk supplies. While this test was first introduced into this country by Ramsdell [17] in 1935, one factor possibly more responsible than any other for delaying its official acceptance was its sensitivity to physiologically abnormal and pathological milks.

If the resazurin test, which is well adapted to farm use through Goldings [8] dry vial modification, can be established as a valuable field test for the detection of mastitis, those working on the control of this disease will have a rapid means of examination of the individual quarters.

The object of this study was to establish the degree of correlation existing between resazurin reduction in freshly drawn quarter samples of milk and tests which have already been accepted for the detection of mastitis. If such a correlation can be established, the resazurin test will then be suitable for the rapid detection of mastitis on the farm, as well as for the routine grading of raw milk at the plant.

## REVIEW OF LITERATURE

A complete review of literature relating to mastitis infection and diagnosis was not attempted, due to the tremendous volumes that have been written on this subject. The following, therefore, is intended to familiarize the reader with the resazurin test and the chemical and bacteriological tests used in this study.

In the routine grading of raw milk supplies, the resazurin test is run on milk samples lifted at the weigh tank, and usually consists of a composite sample of mixed night and morning milk. Reduction of the dye depends upon the kind and number of bacteria present and the degree of abnormality. When milk is normal, with a low bacterial count, the reduction will be gradual from the original blue to white. When the bacterial count is high, that is in terms of millions, the reduction will be rapid, going from the original blue through pink to white. The same will be true of milk having a high bacterial count accompanied by large numbers of leucocytes. On the other hand, when the bacterial count is low and there is a high leucocyte count, there will according to Davis,[6] Johns,[11] Little[13] and Ramsdell [17] be a rapid reduction to pink followed by a lag phase, with the final reduction to white being brought about by the gradual increase in bacterial numbers.

Davis [6] claims that when the resazurin test is run on milk that is less than four hours old, the resazurin reduction is a measure of leucocyte activity only.

According to Burkey,[20] normal milk from a healthy udder is free from mastitic-causing organisms, contains relatively few leucocytes, contains less than 0.10 percent chlorides, and has a pH value of about 6.5. The presence of excessive numbers of leucocytes is an indication of inflammation and is the basis of the catalase test.[20] An arbitrary number of 100,000 leucocytes per ml has been considered by some investigators [7, 9] as the upper limit for normal milk, while Little [14] has designated 300,000, and Hucker [10] and Burkey [20] 500,000. Rosell [18] found that a concentration of chlorides greater than 0.14 percent and a pH value of 6.8 or higher is indicative of mastitis. Cone [5] found that in periodic examinations of milk from a cow, abrupt increases in the number of leucocytes and in the percentages of chlorides indicate the onset of mastitis, and that of these two criteria the leucocyte count is the more reliable index of infection. It has been shown [1, 2] that the changes that occur in mastitic milk, arranged sequentially in the order of appearance are: the presence of causative organisms; increase in leucocytes; increase in the percentages of chlorides; and finally, an increase in the alkalinity of the milk. The last named change usually occurs after the peak of the infection. On the other hand, the presence of large numbers of leucocytes, high catalase values, milk clots, increased percentages of chlorides, and increases in the pH values are not always correlated with the presence of typical bacteria causing mastitis.[1, 2, 12] Burkey *et al.*[19] maintains that the mere presence of mastitic-producing organisms, particularly streptococci in the milk, is not always coincident with infection and is not a reliable indication of established infection.

It is clear from the above that the tests for abnormal milk or mastitis are a measure of degree, rather than a pos-

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[2] Supported by research grant from American Dairy Association. Washington State Dairy Products Commission.

[3] The experimental data in this paper are taken from a thesis submitted by the senior author in partial fulfillment of the degree of Master of Science in Agriculture, 1950.

itive statement of the presence or absence of infection.

## EXPERIMENTAL

*Presumptive screening.* To avoid the unnecessary work and loss of time through the routine examination of many samples of normal milk, a screening procedure was adopted using catalase and pH determinations in preliminary examination. Where quarter samples showed either a gas production of 10 percent or more by the catalase test, or a pH value of 6.65 or higher, the milk from that quarter was routinely examined using five confirmative tests.

*Confirmative testing.* The composition of mastitic milk changes very rapidly. Because of this, the fresh samples for the confirmative tests were run as soon as possible after screening, usually within 24 hours. The confirmative tests included: the leucocyte count, chloride, catalase and pH determinations, and the hemolytic count on blood agar. For supporting information, it was thought desirable to make standard plate counts on all samples examined.

*Sampling.* The samples for screening, and later for confirmative testing, were collected from each quarter at the beginning of the evening milking. With one exception, the quarters showed no signs of physical abnormalities. The udder, flank, and teats were washed with water containing a disinfectant and then wiped practically dry. The first three streams were discarded from each quarter, after which a sterile 3-ounce screw-capped sample bottle was filled directly from the teat and capped immediately. The samples were placed in a box containing ice and taken immediately to the laboratory. At no time did more than one and one-half hours lapse from the time that the first samples were drawn until testing was begun.

The resazurin test, using Golding's dry vial modification,[8] the standard plate count, and the hemolytic counts was made according to the procedure outlined in Standard Methods. The chloride determinations were made by measuring the electrical conductivity of the milk, using McCulloch's electrometric method.[15, 16] The procedure for the catalase test was the same as adopted by Halversen.[9] A Beckman industrial potentiometer was used for determining the pH values.

The following criteria were used to present an evaluation of mastitic conditions as determined by the examination of samples of fore-milk from individual quarters: Mastitic or abnormal milk was considered to be milk containing 100 (lower limit of quantitative count used) or more hemolytic colonies per ml on blood agar, 500,000 or more leucocytes per ml, 16.6 percent or more catalase, 0.10 percent or more of chlorides, and milk with a pH value of 6.8 or higher.

## EXPERIMENTAL RESULTS

In all, 985 presumptive screening tests were run. This screening procedure showed that 269 quarters were producing milk of a mastitic-like nature. The resazurin triple-reading and confirmative tests were run on the milk from these quarters.

The results of the resazurin reduction at the end of one, two, and three hours incubation, compared with the means for the confirmative tests, are shown in table 1.

TABLE 1

COMPARISON OF THE RESAZURIN READINGS WITH THE MEANS OF READINGS OBTAINED WITH THE CONFIRMATIVE TESTS

| Period of incubation | Resazurin reading | No. of samples | Catalase percent gas | pH | Chlorides percent | Leucocytes (000) | Hemolytic count | Standard plate count |
|---|---|---|---|---|---|---|---|---|
| One hour incubation | 1 | 61 | 8 | 6.67 | 0.085 | 156 | 734 | 1,411 |
| | 2 | 70 | 21 | 6.68 | 0.095 | 990 | 3,458 | 9,220 |
| | 3 | 60 | 51 | 6.78 | 0.111 | 2,228 | 4,852 | 14,955 |
| | 4 | 53 | 72 | 6.81 | 0.125 | 5,501 | 19,173 | 23,726 |
| | 5 | 25 | 87 | 6.99 | 0.161 | 19,604 | 42,732 | 68,640 |
| Two hour incubation | 1 | 29 | 3 | 6.69 | 0.084 | 69 | 510 | 1,238 |
| | 2 | 62 | 13 | 6.65 | 0.091 | 338 | 794 | 3,471 |
| | 3 | 42 | 27 | 6.71 | 0.092 | 1,377 | 6,564 | 12,164 |
| | 4 | 83 | 53 | 6.77 | 0.112 | 2,890 | 8,716 | 14,687 |
| | 5 | 53 | 84 | 6.93 | 0.150 | 12,708 | 30,632 | 48,030 |
| Three hour incubation | 1 | 3 | 0 | 6.63 | 0.085 | 26 | 100 | 2,300 |
| | 2 | 56 | 6 | 6.67 | 0.085 | 123 | 616 | 1,346 |
| | 3 | 44 | 20 | 6.67 | 0.096 | 715 | 1,518 | 4,959 |
| | 4 | 99 | 42 | 6.74 | 0.103 | 2,062 | 9,134 | 16,851 |
| | 5 | 67 | 85 | 6.92 | 0.145 | 11,315 | 25,086 | 39,205 |

As the reduction of resazurin in milk was continued from one to three hours, there was a gradual lowering of the means for the confirmative tests when compared with the means of these at the previous hour. This is no doubt due to the inclusion in the higher resazurin readings at the second and third hour of samples that show a lesser degree of abnormality than those samples considered positive by the resazurin after one hour incubation. The number of samples with a resazurin reading of 1 after one hour incubation was 61, compared with 29 after two hours and 3 after three hours incubation. The number of samples with a resazurin reading of 5 increases with each additional hour incubated.

On the basis of a one hour incubation and a resazurin reading of 5, the resazurin test identifies the more severe cases of sub-clinical mastitis.

Twenty-five samples were completely reduced to 5 within one hour. From data not presented, two of these were completely reduced to white within ten minutes. In neither case was there a standard plate count exceeding 6,100 bacteria per ml, even though they both had exceedingly high leucocyte counts and were abnormal in appearance.

In table 2 will be found the range for the confirmative tests at each incubation period and for each reading in the resazurin reduction.

A comparison of the confirmative tests with resazurin readings at different incubation times can best be made from a study of table 3. From these results, it is apparent that the catalase and leucocyte determinations were the two confirmative tests most useful in differentiating between normal and abnormal milk. Resulting from the examination of 269 quarters by the confirmative tests, 187 were considered abnormal on the basis of catalase and 185 by the leucocyte count. The hemolytic count detected 164 and the chloride and pH detected 138 and 83, respectively.

On the basis of the confirmative tests, the results appearing in table 3 would indicate that the resazurin test using a resazurin reading of 3 and a one hour incubation, or a resazurin reading of 4 on two hours incubation, would be

TABLE 2

COMPARISON OF RESAZURIN READINGS WITH THE RANGE FOR THE CONFIRMATIVE TESTS

| Period of incubation | Resazurin reading | No. of samples | Catalase percent gas | pH | Chlorides | Leucocytes (000) | Hemolytic count |
|---|---|---|---|---|---|---|---|
| | | | | | | | ** |
| One-hour incubation | 1 | 61 | 0–40 | 6.45–6.99 | 0.060–.118 | 0– 156 | 100– 15,700 |
| | 2 | 70 | 0–85 | 6.43–7.24 | 0.055–.195* | 0– 9,292 | 100–100,000 |
| | 3 | 60 | 15–95 | 6.47–7.37 | 0.069–.195 | 309– 7,168 | 100– 80,000 |
| | 4 | 53 | 30–95 | 6.53–7.40 | 0.078–.195 | 1,194–23,895 | 100–250,000 |
| | 5 | 25 | 70–95 | 6.73–7.35 | 0.102–.195 | 1,000–58,675 | 200–600,000 |
| Two-hour incubation | 1 | 29 | 0–20 | 6.45–6.83 | 0.063–.115 | 0– 354 | 100– 17,600 |
| | 2 | 62 | 0–40 | 6.43–6.99 | 0.055–.155 | 0– 3,540 | 100– 15,700 |
| | 3 | 42 | 0–85 | 6.46–7.24 | 0.058–.195 | 35– 9,292 | 100–100,000 |
| | 4 | 83 | 15–90 | 6.47–7.37 | 0.069–.195 | 380–18,319 | 100–250,000 |
| | 5 | 53 | 40–95 | 6.59–7.40 | 0.078–.195 | 1,000–58,675 | 100–600,000 |
| Three-hour incubation | 1 | 3 | 0–0 | 6.45–6.72 | 0.080–.092 | 0– 53 | 300– 300 |
| | 2 | 56 | 0–30 | 6.50–6.83 | 0.060–.115 | 17– 628 | 100– 15,700 |
| | 3 | 44 | 0–40 | 6.43–6.99 | 0.055–.155 | 0– 9,292 | 100– 16,800 |
| | 4 | 99 | 10–90 | 6.48–7.24 | 0.060–.195 | 309– 7,160 | 100–250,000 |
| | 5 | 67 | 40–95 | 6.53–7.40 | 0.078–.195 | 1,000–58,675 | 100–600,000 |

* Highest limit of quantitative determination
** Lower limit of quantitative count used.

From the data presented in table 4, it is evident that the correlation between resazurin reduction and the confirmative tests used is highly significant at the 1 percent level.

## DISCUSSION

Several investigators [3, 4, 19, 20] have emphasized the importance of leucocytes in detecting mastitis. From the data presented in this study, it is apparent that resazurin is very sensitive to freshly drawn milk containing large numbers of leucocytes. When a three-hour incubation time and a resazurin reading of 3 is used as a confirmative test, this test will detect 98.4 percent of those samples which had a leucocyte count of 500,000 or more per ml.[19] It should be noted, however, that on the basis of this criterion the mean leucocyte count was 715,000 per ml. While resazurin detected 28 more samples than considered positive on the basis of the leucocyte count, six of these were found, from data not presented, to have a hemolytic count above 1,000 bacteria per ml. The greater sensitivity of resazurin in detecting this type of milk would appear to be an advantage rather than a limitation of the test.

TABLE 3

COMPARISON OF RESAZURIN READINGS WITH THE NUMBER AND PERCENT OF SAMPLES CONSIDERED POSITIVE* BY CONFIRMATIVE TESTS

| Period of incubation | Resazurin reading | No. of samples | Catalase | | pH | | Chlorides | | Leucocytes | | Hemolytic Count | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. | % | No. | % | No. | % | No. | % | No. | % |
| One-hour Incubation | 1 | 61 | 9 | 6.8 | 7 | 11.5 | 12 | 19.7 | 7 | 11.5 | 15 | 24.6 |
| | 2 | 70 | 41 | 58.6 | 7 | 10.0 | 22 | 31.4 | 42 | 60.0 | 39 | 55.7 |
| | 3 | 60 | 59 | 98.3 | 24 | 40.0 | 37 | 61.7 | 58 | 96.7 | 42 | 70.0 |
| | 4 | 53 | 53 | 100.0 | 23 | 43.4 | 42 | 79.2 | 53 | 100.0 | 44 | 83.0 |
| | 5 | 25 | 25 | 100.0 | 22 | 88.0 | 25 | 100.0 | 25 | 100.0 | 24 | 96.0 |
| Two-hour Incubation | 1 | 29 | 1 | 3.4 | 1 | 3.4 | 6 | 20.7 | 0 | 0.0 | 6 | 20.7 |
| | 2 | 62 | 20 | 32.3 | 5 | 8.0 | 17 | 27.4 | 15 | 24.2 | 21 | 33.9 |
| | 3 | 42 | 31 | 73.8 | 7 | 16.7 | 10 | 23.8 | 35 | 83.3 | 28 | 66.7 |
| | 4 | 83 | 82 | 98.8 | 31 | 37.3 | 54 | 65.0 | 82 | 98.8 | 61 | 73.5 |
| | 5 | 53 | 53 | 100.0 | 39 | 73.6 | 51 | 96.2 | 53 | 100.0 | 48 | 90.6 |
| Three-hour Incubation | 1 | 3 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 33.3 |
| | 2 | 56 | 6 | 10.7 | 4 | 7.1 | 10 | 17.8 | 3 | 5.3 | 14 | 25.0 |
| | 3 | 44 | 23 | 52.3 | 6 | 13.6 | 17 | 38.6 | 20 | 45.4 | 18 | 40.9 |
| | 4 | 99 | 91 | 92.0 | 25 | 25.2 | 50 | 50.5 | 95 | 95.9 | 74 | 74.7 |
| | 5 | 67 | 67 | 100.0 | 48 | 71.6 | 61 | 91.0 | 67 | 100.0 | 57 | 85.0 |

* Catalase 16.6%; pH 6.8; Chloride 0.10%; Leucocytes 500,000; Hemolytic Count 100.

equally sensitive when compared with the confirmative tests in differentiating between normal and abnormal milk. Little advantage was gained from the longer incubation time.

If a three-hour incubation and a resazurin reading of 3 or mauve-pink be chosen as a criterion for differentiating between mastitic and normal milk, then 96.7 percent of the quarters were positive on the basis of the catalase test, 95.2 percent on the basis of pH, 92.7 percent on the basis of chlorides, 98.4 percent on the basis of leucocytes, and 90.8 percent on the basis of the hemolytic count. Using the same criterion, 210 quarters would have been graded positive by the resazurin test compared with 181 by catalase, 79 by pH, 128 by chloride, 182 by leucocytes, and 149 by the hemolytic count. Resazurin seems to be more sensitive to this abnormal milk than any of the confirmative tests used.

TABLE 4

COMPARISON OF THE CORRELATIONS OF THE RESAZURIN READINGS WITH CONFIRMATIVE TESTS

| Incubation in hours | Percent catalase | pH | Percent chloride | Leucocyte count | Hemolytic count |
|---|---|---|---|---|---|
| 1 | +0.450* | +0.794 | +0.647 | +0.571 | +0.309 |
| 2 | +0.465 | +0.810 | +0.630 | +0.479 | +0.382 |
| 3 | +0.462 | +0.798 | +0.589 | +0.469 | +0.630 |

* n equals 219, otherwise the n value was 269.

The lag phase reported by Davis,[6] Johns,[11] Ramsdell,[17] and Little [13] to occur during the reduction of this dye in milk containing large numbers of leucocytes was not observed in the 25 samples which were completely reduced to white in one hour. The fact that in no case was the standard plate count above 800,000 bacteria per ml eliminates any possibility of bacteria completing the reduction of the dye. The fact that two samples which were completely reduced in ten minutes had plate counts of 6,100 bacteria per ml or less substantiates this.

The observation made by Davis [6] that when the resazurin test is run on milk samples within four hours of milking, it is a measure of leucocyte activity only, was confirmed in this study.

The close relationship found by Ramsdell [17] to exist between resazurin reduction and catalase was evident in this study, since the resazurin test detected 96.7 percent of the samples that were positive on the basis of the catalase test. This correlation is important since Rosell [18] claims that the catalase test will detect from 80 to 90 percent of the mastitis cases.

Burkey [19] considers milk regularly containing more than 100 infecting bacteria but not more than 10,000 per ml, more than 500,000 leucocytes but rarely more than 1,500,000 per ml, and more than 0.09 but rarely more than 0.12 percent chlorides as positive mastitis. It is evident from the data presented that, when using a three-hour incubation with a resazurin reading of 3 as a standard, 15 quarters having a hemolytic count greater than 100 bacteria per ml were missed. Two of these samples had hemolytic counts greater than 10,000 per ml. From data not presented, one of these samples contained 13,600 hemolytic bacteria per ml and was negative to the other confirmative tests. This is a good example of the presence of incriminating bacteria without accompanying inflammation. Whether such a quarter would be diagnosed as mastitic is doubtful.

While the correlation between resazurin reduction and the chloride and pH determinations was highly significant, these two confirmative tests detected only 128 and 79 samples, respectively, of the 210 considered positive by resazurin. Resazurin, on the other hand, detected 92.7 and 95.2 percent of the samples considered positive on the basis of the chloride and pH determinations respectively.

When this study was begun, the object was to determine the correlation between resazurin reduction with some of the more common tests used to detect mastitis. Since a significant correlation was found to exist, it is possible to use the dry vial modification of the resazurin test [8] as a screening test for mastitis infection on the farm. Little previous consideration has been given to the use of this test for the diagnosis of mastitis.

## CONCLUSIONS

1. The correlation of resazurin reduction in freshly drawn quarter samples of mastitic-like milk with the confirmative test used is highly significant.

2. When the resazurin test is run on quarter samples of milk within four hours of milking, it is a measure of leucocyte activity only.

3. Resazurin dye in freshly drawn quarter samples of mastitic-like milk may be reduced to colorless, and the lag phase as previously reported is not noted under such conditions.

4. The bacteria present in such mastitic-like milk are not sufficient to affect the reduction.

5. A resazurin reading of 3 on a one-hour incubation, or preferably a resazurin reading of 3 on three-hour incubation, can be used as a suitable criterion for detecting cases of subclinical mastitis.

6. The resazurin test, using the dry vial modification when supervised by a competent fieldman, can be used to advantage on the farm as a screening test for mastitis.

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# MILK and FOOD SANITATION

## LET US CONSIDER OUR SANITARY MILK LEGISLATION

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FEW of the younger men in the field of milk sanitation fully realize the great progress that has been made in the quality of milk during the last half century. In the interest of a correct setting of this improved quality it should be stated that the same general trend occurred in most foods.

Milk-borne disease epidemics are local in nature so that the local boards of health became active as soon as the source of such diseases became known. At the close of the last century there was only limited knowledge on the sanitary production of milk and the control of infectious diseases. Consequently, local boards of health had to recommend ordinances to regulate milk production and handling without all of the knowledge necessary to do so. The various cities passed a variety of regulations but as knowledge and experience have accumulated these sanitary milk regulations have tended to become more uniform. . . . Probably there is more uniformity in basic essentials of sanitary milk production than is generally recognized but conditions vary across the United States.

### OBJECTIVES OF SANITARY MILK LEGISLATION

The primary objective of sanitary milk legislation is safe milk for the consuming public. Safety refers primarily to freedom from living, disease-producing bacteria and the toxins of some bacteria that may be dead. These two elements of safety can be guaranteed only by the production of milk of relatively low bacterial content and the perfect pasteurization of such milk with no subsequent contamination. . . .

Surely the physical cleanliness of milk may be so closely related to general wholesomeness that there is every reason to consider it to be a public health program.

Consumers should be supplied with milk that is nutritious, possesses a good flavor, and will keep well under refrigeration for the period of time necessary under common practices in the handling of milk. . . .

### CONSIDERATION OF UNIFORM REGULATIONS

In those early days of the beginning of sanitary milk regulations, only the local needs of the community needed consideration. . . . Any sanitary legislation that satisfied a local market and producing area was acceptable.

However, as cities grew in size and the per capita consumption of milk increased, it became essential to enlarge their milk sheds and to ship milk from the producing area of one city to the market of another city. . . . As a result of this natural nutritional and economic development, the sanitary legislation of one city was enforced upon the milk producers in another area and differences in regulations became evident and somewhat troublesome. . . .

### THE NATIONAL RESEARCH COUNCIL PROJECT

The project on milk quality and milk regulations of the National Research Council is under the supervision of the Committee on Milk Production, Distribution and Quality, of which Dr. W. E. Krauss is Chairman. The Committee operates jointly under the Food and Nutrition Board and the Agricultural Board. The general plan and outline of the project were formulated by this Committee, and I care for the details of execution of the research. The project is under contract with the United States Department of Agriculture and is financed by the Research and Marketing Act.

The first part of the project consisted of a tabulation of all state laws and city ordinances in municipalities of 100,000 population or over (1940 census) as they existed in 1949. This part of the project has been completed and will be available soon as a publication of the National Research Council.*

The second part of the project is now under way. It deals with the influence of the city ordinances, enforcement procedures, and educational and commercial programs in selected cities on the quality of the milk supply. It is hoped that sufficient numbers of cities can be studied to obtain sufficient data for some definite conclusions. . . .

Some details of the study now in progress will show the character of the research. The assistant director of the project who is experienced in milk sanitation, and a laboratory technician, work for three or four weeks in each city at two different times. They collect samples of raw vat milk, pasteurized milk, and pasteurized cream which are analyzed for total, thermoduric, and coliform bacterial counts, and sediment in a local city laboratory by the laboratory technician. Then samples of pasteurized milk are packed and shipped to a central laboratory in St. Paul, Minnesota, where they are tested for phosphatase, flavor, total and coliform bacterial counts, and keeping quality for seven days. The usual nutritive value of the milk is also determined. It should be stated that the travelling bacteriologist has been instructed in the central laboratory so that methods and media are identical. The milk sanitarian scores the milk plants and farms and evaluates the effort of the sanitary milk program of the health department. Consideration is also given to the efforts of the milk companies and farm organizations. It should be evident that the study is rather extensive and detailed for this is essential to obtain ample data to establish facts.

### LAWS AND THE ENFORCING AGENCIES

Let us consider some of the existing laws and ordinances. Replies were received from the state departments of health and of agriculture in all 48 states. Of the 92 cities with populations of 100,000 or more (1940 census) there were 88 that replied and 84 had ordinances avail-

* Condensation of paper presented at Fourth Annual Meeting Dairy Products Improvement Institute, Inc., Hotel Commodore, New York City, January 11, 1951.

* See review on page 3.

able. This cooperation was particularly good.

At the state level, the enforcement of laws was vested in the department of health in 22 states, in the department of agriculture in 21 states, in both departments in 3 states, and in other agencies in 2 states. The general style and details of the Milk Ordinance and Code Recommended by the United States Public Health Service was followed in 27 states.

The responsibility for sanitary milk control was vested in the city boards of health of the 84 cities except for a few instances where the city-county health units had jurisdiction. The state laws were the basis of local ordinances in 23 cities; 20 cities had individual local legislation; and 41 cities had ordinances patterned after the United States Public Health Service Ordinance.

The majority of states and cities had passed new sanitary legislation since 1945 and only a few laws and ordinances had not been revised, amended or rewritten since 1940.

### GRADES OF MILK AND BACTERIAL COUNTS

There were 11 states with no defined grades of milk; 12 states provided for 3 or more grades of raw milk; and 14 states defined 3 or more grades of pasteurized milk. Two states prohibited the sale of raw milk at retail. About half of the cities permitted the sale of only one grade and 9 allowed the sale of 3 grades of pasteurized milk. The sale of retail raw milk was prohibited in 51 cities.

Bacterial count standards for the best grade of retail raw milk were established at 35,000 to 50,000 per ml in 27 states. Brucellosis-free herds were required in 32 of the 46 states permitting the sale of raw milk at retail. For cities, the most prevalent bacterial count standard for retail raw milk was 10,000 per ml and 11 of the 33 cities permitting the sale of raw milk did not require brucellosis-free herds. It should be pointed out that healthy dairy cattle were required in legislation of 45 states and 78 cities. Nearly all of this legislation specified cattle free from tuberculosis. Healthy udders were required in 27 state laws and 57 city ordinances.

Bacterial standards for the best grade of prepasteurized milk were established in 37 states with 100,000 to 200,000 per ml predominating. The best grade of pasteurized milk had bacterial standards of 15,000 to 30,000 per ml in 36 states. The predominating standard for the best grade of prepasteurized and pasteurized milk in cities generally agreed with state standards.

The bacterial standards for cream were usually double those established for milk but other sanitary standards for milk and cream were comparable. However, fewer states and cities established a bacterial standard for cream than was true for milk. Twenty states and 15 cities had no bacterial standards for cream.

### DAIRY FARM SANITATION

The milk house was universally required, and 85.4 percent of the state laws and 83.3 percent of the city ordinances did not prohibit the milk house from being an integral part of the dairy barn. In 41 states and 82 cities the milk had to be strained in the milk house, thus making this feature one of the most common of all regulations.

Let us consider so simple a regulation as that requiring that milk must be strained in the milk house just to illustrate that the issues are not so clearcut and obvious as some individuals wish them to be. There were 82 cities or 97.6 percent which required straining in the milk house and it should not be presumed that a regulation common to practically all ordinances is necessarily essential. In the first place it is evident that this regulation increases the labor for milk production. Recently I was in a dairy barn where one man during milking used his entire time carrying milk by the pail from the barn to the milk house. Secondly, there are no experimental data showing that the quality of milk is better when strained in the milk house rather than in the barn. I presume this requirement was introduced when barns were often insanitary and not even proper places for milking. . . . It is debatable as to the desirability of permitting any straining of milk on the farm.

. . . Milk is essentially always as clean as it was before the extraneous matter was removed and only its appearance is improved. . . .

Small-top pails were required by 30 state laws and 51 city ordinances. Only 10 state laws and 27 city ordinances mentioned milking machines. The laws of 9 states and 9 cities failed to mention the "sterilization" of equipment. The majority of state laws and city ordinances permitted "sterilization" by chemicals, hot air, hot water, steam, or by an approved method. Hot water or steam only was required by 1 state and 12 cities, steam only by 1 city, hot water only by 1 state and 4 cities, and chemical sterilization only by 1 city.

Although most regulations do not specify how prepasteurized milk should be cooled on the farm, there were 5 cities that referred to mechanical refrigeration. Eight states and 28 cities made mention of water cooling tanks. There were 8 states and 4 cities whose legislation did not establish any temperature for milk as delivered to the plant by the producer. The state laws generally required that milk be cooled below 55 or 60° F and city ordinances generally required a cooling temperature of 50 or 60° F.

### SOME PASTEURIZATION PLANT REQUIREMENTS

Separate rooms for receiving milk, washing bottles, pasteurization, and processing were required in 37 states and 69 cities. Slightly less than these numbers required a covered milk coolor or separate room for cooling pasteurized milk.

Pasteurization at 143° F for 30 minutes or 160° F for 15 seconds was almost universal except that the legislation of 7 states and 22 cities did not define high-temperature short-time pasteurization.

The protection of the pouring lip of the milk bottle was required by 18 states and 53 cities. The date of pasteurization or sale of the milk had to be printed on the bottle cap in 2 states and 12 cities.

### THE BASIS FOR RECOMMENDATION OF REGULATIONS

Facts established by carefully conducted research are the only basis for any reconsideration of sanitary milk legislation in the future. Certainly the progress of the past has been based both upon trying unknown procedures and upon known facts. In the future more emphasis can be given to acceptable knowledge in the formulation of sanitary milk regulations as information is now so extensive, based both upon the results of research and upon observations from the effects of regulations. . . .

# "INTEGRATED SUPERVISION OF MILK QUALITY CONTROL" *

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THE supervision of the quality of milk supplies is pre-dated, as a concept of public health practice, by many hundred years of regulations pertaining to other foods, to be found in the legal lore of those times. The profession of milk quality supervision in this country today is, in effect, a big business. Essentially every state has at least one, or two, or three or more official departments administering the concept of its laws or regulations on milk and its products, particularly with respect to standards of quality. Essentially every one of some 477 cities of 25,000 or more inhabitants has individual community rules or regulations; then of course there is a tremendous number of other political areas, such as smaller communities, counties, townships, or joint city-county, or joint city, or joint county areas, administering supervision of milk quality. The magnitude of the industry is recognized in the operation of separate departments of dairy industry, husbandry, technology or manufactures, in nearly every state College of Agriculture; few, if any, other food industries have such academic recognition. The magnitude of the profession of the Milk Sanitarian is to be seen in the professional organization, THE INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, which in its parent, and through its some twelve regional affiliate organizations, consists of over three thousand members, and which publishes a professional Journal, the *Journal of Milk and Food Technology (Milk and Food Sanitation)*. In addition, there exists other professional groups whose vocation deals with matters pertaining to milk and milk products quality, such as the American Dairy Science Association, American Society of Bacteriologists, dairy fieldmen's associations, American Public Health Association, and so on.

* Condensation of paper presented at Fourth Annual Meeting Dairy Products Improvement Institute, Inc., Hotel Commodore, New York City, January 11, 1951.

## INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS

The INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS previously was known as the Association of Milk Inspectors. Obviously, responsibility for milk quality supervision developed professionally, not only with those responsible for supplies for communities, but also with those engaged in procurement, and in distribution. The Association of Milk Inspectors became an Association of Milk Sanitarians, and through its affiliate regional memberships, includes those whose activities involve other than official matters in milk and milk products quality.

This Association, in its official work, has consistently undertaken review of current pertinent matters in milk sanitation through the activities of certain standing, and assigned task, committees. In effect, the work these Committees have done, is definitely in the direction and integration of supervision of milk quality control.

## 3A STANDARDS

The sanitary design of milk equipment has, in sanitation parlance, assumed an ever-increasing importance in the acceptability of milk, and its products, as a food, particularly in the protection of them after pasteurization. While ordinances and codes stipulated the basic concepts in sanitation, there existed divergence in detailed requirements in design for the equipment. There came about a strong need for public health justification of many of the sanitary standards in existence.

Through the interest of certain industry and sanitation groups, and considerable group discussion of leaders in various branches of the industry, there developed a procedure for the establishment of minimum sanitary standards for specific units of equipment common to various processing operations. Specifically, there now exists joint action between three groups:

### 3A COMMITTEE MEMBERSHIP

(a)

*Sanitary Standards Sub-Committee of The Dairy Industry Committee Representing:*

Dairy Industry Supplies Assn.
American Dry Milk Institute
Evaporated Milk Association
Milk Industry Foundation
International Association of Ice Cream Manufacturers
American Butter Institute
National Cheese Institute

(b)

*International Association of Milk and Food Sanitarians*

Sanitary Procedures Committee

(c)

*United States Public Health Service*

Milk and Food Section

Through the work of assigned task committees, and sub-committees of the three groups, there have been established fundamentals in the design of a number of units of equipment, including some 40 sanitary fittings, thermometer fittings, storage tanks, milk pumps, weigh cans and receiving tanks, homogenizers, automotive transportation tanks, electric motors and attachments, can-type strainers, filters using disposable media, and continuous pasteurizer holding time procedure. Units under consideration include plate-type, and tubular-type heat exchangers, can washers and milking machines; units planned for assignment include leak-detector, plug-type valves, threads in the milk zone, the washing of pipe lines in place, batch pasteurizers, factory separators and clarifiers, bottle fillers and cappers, farm coolers, and ten-gallon shipping cans.

The role of the International Association of Milk and Food Sanitarians in this work is two-fold: through its *Committee on Sanitary Procedures,* the Chairman of which is C. A. Abele, of Evanston, which participates in the counsel given in consideration in establishment of the fundamentals; in the submitting of the tentative standards to the Association for review and acceptance, and, finally, in the publishing of the standards in its *Journal of Milk and Food Technology (Milk and Food*

*Sanitation)*, as 3A Sanitary Standards, the 3A symbol being the property of the Association. Equipment meeting the published standards may bear the 3A symbol. Copies of the 3A Standards, published to date, are available from George West, Secretary, International Association of Milk and Food Sanitarians, care of Rochester Health Department, Rochester, New York, at $1.25 per set.

### AMERICAN PUBLIC HEALTH ASSOCIATION

The desirability of, and the problems in integrated milk quality supervision, have been the subject of intense concern by several investigating groups. In 1946 a subcommittee on Reciprocal Sanitary Milk Control was appointed by the Committee on Administrative practice of the American Public Health Association for the purpose of studying the complex system employed for the procurement of milk supplies for states and municipalities. In the report of this sub-committee in 1948 it was brought out that notwithstanding the increased population and increased demand for milk, the total number of cows in the United States has not increased materially over that of 15 years ago. Milk sheds of large cities are contiguous or overlapping. There exist many barriers limiting importation of milk, or cream, tied to conditions of time, and approval, and use. The report emphasized that no matter how much health officials may wish to do so, economics cannot be divorced from public health of milk supplies. All control measures are bound to have some effect on cost or prices. The best that can be done to minimize the effect of sanitary control on costs and prices is to employ sanitary regulations with simplicity, with uniformity, and to provide uniformity in enforcement that eliminates duplication or multiplication of control.

### NATIONAL CONFERENCE ON INTERSTATE MILK SHIPMENTS

One of the current important activities in the integration of Supervision of Milk Quality Control, is that of the National Conference on Interstate Milk Shipments,* first held June 1–3, 1950, in St. Louis, and scheduled there again this year for June 4–6, 1951. Through the activities of assigned task forces, basic policies were established in facilitating and expediting the interstate shipment of milk supplies of approved quality. In substance, there was established recognition of the United States Public Health Service Milk Ordinance and Code (1939) as the basic regulation, compliance with which is measured by the United States Public Health Service milk sanitation rating. Approximately 30 states have agreed to utilization of the plan, about half of which are currently receiving states.

The interstate plan is being followed similarly in the State of Minnesota; several other states are contemplating the machinery by which it may be invoked.

There are some pertinent effects of the introduction of such an integrated plan for supervision of milk supplies as has occurred in Wisconsin.

The State of Wisconsin recently established revised regulations on the production and handling of milk. Through the employment of the revised standards, as well as in the meeting of the requirements of the Interstate Certification Plan, there has been a distinct improvement in the uniformity of quality of milk in the state.

Where dairy plants develop supplies of certifying quality, there becomes available at times a surplus of milk that perforce is converted to manufactured products; in one instance it is processed into cheese, in others into butter. The effects, of course, are to upgrade the quality of the manufactured products. The introduction of the new quality standards in certain areas, has affected the milk quality programs in others. There has been a noticeable effect upon the quality levels of ice cream mix, and ice cream, with the advent of newer state standards.

Many small communities are without local supervisory quality programs for their milk supplies; while one group of communities had already joined together in operation of a supervisory center, the effects of the interstate program in emphasizing certification requirements in nearby areas have resulted in consideration of a joint plan of supervision by six small cities nearby.

One of the specific problems in the integration of milk quality supervision such as has occurred and is occurring in Wisconsin, is the difficulty of procuring a complement of personnel qualified to assume responsibilities for the task. In the state agency levels, some eight to ten additional men are needed to carry the supervisory work load.

### MULTIPLE INSPECTION

Local prides, and local reactions, are always problems in integrating activities. It must be admitted that local supervisory services are not always better than over-all programs; evaluation of the status quo is not always pleasant news. One of the major problems facing producing areas without benefit of an integrated supervision plan is the multiplicity of inspections, or appraisals by sanitarians. It is entirely proper to point out that under the circumstances it is evident sanitarians are not necessarily appraising facilities, and methods, but rather the competence, or incompetence, of one another. In the light of the diverse points of emphasis brought forth in these frequent appraisals, the need for integration in the concept of what actually is required in sanitation, is very evident.

### BASIC TENETS NEEDED

The activities that have been reviewed herein cover a period of some ten years, many of them have, in fact, become operative only within the past five or two years. There is ample evidence that on professional levels sanitarians can establish a meeting of the minds on what are basic tenets of milk sanitation. It is established that acceptance of these basic tenets is possible, and that machinery can be created by which they can be put into use. The facts are that integration of supervision of the quality of milk supplies enlarges the supply for receiving markets, increases the potential market for shippers, and, eventually, must lower the cost, with increased utilization of milk supplies by and for consumers. In the light of the intense interest in this problem by responsible sanitarian groups, real progress in integration of supervision is being made.

* Reported in this *Journal*, 13, 194 (1950).

# MILK PLANT EQUIPMENT AND SANITATION*

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THE highly perishable nature of milk and its potential role as a carrier of disease influenced sanitarians to show a great interest in all phases of the handling of this product, and it was quite natural that plant and equipment should come in for considerable attention. Sanitarians had no particular guide to follow in judging equipment and there is no doubt that many divergent opinions and ideas were put forth as to what was satisfactory or unsatisfactory.

As far as equipment is concerned, ideas of sanitary construction gradually crystallized to embrace a number of broad principles:

1. Pasteurization equipment had to be so designed that a safe product could be produced.
2. Equipment had to be easily cleanable.
3. Equipment had to be easily dismantleable.
4. Equipment had to be built so as to facilitate a thorough inspection.

Of course, many refinements under each of these broad specifications have been applied as experience developed and I shall try to outline some of these refinements and interpretations.

## SAFETY FEATURES OF EQUIPMENT

Under item one, such points as elimination of pockets and dead ends, providing satisfactory agitation, insulation of covers, reliable heat control instruments such as thermometers and recorders, use of leak protector valves, close-coupled valves, air-space heaters, accurate timing devices, and flow-diversion valves are all illustrative of factors which have a bearing on whether or not the equipment is capable of producing properly pasteurized milk. These things must be built into the equipment and its necessary auxiliary parts.

We, in the Dept. of Health of the City of New York, also include under this, items which relate to the prevention of contamination during the processing operation. These would include the prevention of grease from gear boxes and oil from bearings getting into the milk zone, the use of drip shields to prevent condensate from getting into the product, properly drained and protected covers on vats, and the use of hoods for conveyor lines as a protection against overhead contamination.

## EASY CLEANABILITY

Under the heading of easy cleanability, we take into consideration such items as:

Types of material (stainless steel or dairy metal).
Smooth, finely polished surfaces.
Elimination of square corners and crevices.
Elimination of threads in the milk zone.
Maximum inside height of storage tanks.
Minimum heights in tank trucks.
Opening up of homogenizer blocks to enable brushing through.
The use of welding instead of soldering.

## DISMANTLEABILITY

Our third item relates to dismantleability of equipment. Every piece of equipment in the milk plant with which milk comes in contact must be taken apart at the end of each day's operation to be cleaned and sanitized. We have found from experience that men will take short-cuts in this operation unless the equipment can be readily taken apart without calling on a machinist or the plant mechanic.

Up until the time that agitators of storage tanks were made easily removable, it was not at all unusual to find that they were hardly ever taken out, and no matter how tightly the opening was sealed, one could always find a decomposed accumulation of milk.

Similarly, the old style homogenizers were so made that pistons could not be readily removed nor cylinder openings brushed through. The packing would get soaked through with milk residue and this material was removed only when the homogenizer was repacked, probably several times a year. Of course, it could be argued that such parts were not immediately in the milk zone, but it was our contention that they were close enough to it to cause a possible contamination of the product.

In a similar way, we required a simplification in the design of many other pieces of equipment such as pumps, valve assemblies for filling machines, baggers, cappers, etc. The use of wing nuts, bayonet locks, and similar simple devices has been encouraged wherever their use was feasible in contrast to the more conventional methods of fastening by the use of regular bolts and nuts, simply because such things make dismantling easier.

## EASE OF INSPECTION

This item goes hand in hand with accessibility for cleaning purposes. We want equipment made so that every bit of its surface can be seen by the employee and the inspector. We cannot tell if cleaning has been proper unless we can see it.

MR. PAUL CORASH is chief of the Milk Division, New York City Department of Health. He has a B.S.C. from Massachusetts Agriculture College and LL.B. from New York Law School. His experience includes several years work in the dairy industry. He has been connected with the New York City Department of Health for 23 years, serving as chief of the Milk Division since 1944.

It was recently necessary for us to require the redesign of an expensive milk filler bowl because it was extremely difficult, if not impossible, for us to see all of the inner surface. If we could not see it for inspection, it was obvious that the clean-up man could not see how he was washing it. In this particular case, it was necessary to enlarge the bowl cover from a diameter of about eighteen inches to over three feet.

Ease of inspection is also the reason why we require sweeps at joints in place of the formerly accepted angles, and why we require removable caps on tube ends which might otherwise be permanently sealed. The features mentioned above are by no means a complete list of the factors that must be taken into consideration in judging the desirability of equipment used in handling milk and milk products, but they are illustrative of the sanitarian's thinking when he deals with these matters.

In concluding my remarks about milk equipment, I should mention that there has been established a group known as the 3A Committee which formulates standards for milk products-handling equipment. This 3A Committee consists of:

(1) The Committee on Sanitary Procedure of the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS.
(2) The Milk and Foods Section of the United States Public Health Service.

* Annual Meeting Central Atlantic States Association of Food and Drug Officials, May 24, 1950, Atlantic City, N. J.

(3) The Dairy Industries Supplies Association.

Representatives of the three groups meet periodically and discuss proposed specifications for dairy equipment. If an accord is reached by all three groups the standards are published as 3A Standards. Of course, these standards have no official basis, but they serve as a guide of acceptability both to users of the equipment and to such control agencies as wish to give them consideration. The 3A Standards are flexible and are subject to revision from time to time as experience dictates. The existence of some sort of standard reduces to a considerable extent the varying demands of large numbers of individual health officers, for equipment construction which might meet their particular fancy.

## PLANT SANITATION

We now come to the plant sanitation phase of our discussion and it is obvious that the problem of maintaining good sanitation is directly related to the plant environment. If premises are dark, gloomy, and poorly ventilated, the inducement for doing a good job on the part of the employees is greatly reduced. That is why we recommend light colored walls, plenty of window space or glass brick, supplemental artificial lighting, and artificial ventilation.

The liberal use of steam and hot water in milk plants leads to high humidity, and unless the air is changed frequently and effectively, condensation takes place on walls, ceilings, and equipment, paint gets discolored and peels, and the workmen are uncomfortable.

## PLANT CONSTRUCTION

We recommend glazed-tile walls in processing rooms because they are easy to keep clean and they do not require frequent repainting. The reduction of maintenance costs through the elimination of painting more than makes up for the higher original cost of tiled walls.

In a similar way, a well-laid tile floor, although originally costing more than a concrete floor, will out-wear the latter and more than make up for the extra initial cost because of longer life and lower maintenance.

We have gotten away from the concept of requiring separate rooms for every little phase of plant operations in our recommendations on new construction. Since milk is now handled almost entirely in completely closed systems, the public health reasons for requiring compartmentation in plant construction are dubious. Reduction in the number of partitions has opened up plants and improved light and ventilation, has reduced building costs, and has eliminated one source of irritation between operators and control officials. Of course, we still require bottle washing rooms to be separated from the processing rooms particularly where the wash rooms are used for case and bottle storage, and we separate some manufacturing operations from receiving rooms, but we believe we are more realistic in our present approach.

One of the important items to which we pay attention when plans for new plants are submitted to us relates to the percentage of space in a plant which is to be occupied by processing equipment. Operators tend to overlook or underestimate their future needs resulting from expanding business. This situation can and frequently does result in a badly overcrowded plant five or six years after its construction, and this makes for poor sanitation.

We try to start a plant off by restricting the floor space to be occupied by equipment to 25 percent of the total floor area. This may seem to be a very low ratio, but by the time equipment is moved two feet away from the walls and the individual pieces of equipment separated by two-foot distances, when allowance is made for portable wash tanks and work tables, and the room gets cut up by conveyor lines and sanitary lines, we wind up with a fairly well-occupied space. Certainly the person who starts out with a reasonable amount of working area has a better chance of our approving additional installations of equipment than the one who is already operating an overcrowded plant.

It should be borne in mind that many aspects of plant sanitation go hand in hand with efficiency of operations. This was touched upon when we spoke of tiled floors and tiled walls. When proposed plant lay-outs are discussed, operators can frequently be convinced to do certain things because it will provide an economic benefit and at the same time bring about a sanitary advantage. The arrangement of a plant, for example, to eliminate passage of traffic through operating rooms, results in a neater and cleaner plant and at the same time reduces interference with operations. In a like manner elimination of plant crowding enables workmen to operate more effectively since they work unhampered and without stumbling over equipment and one another. Placing delicate control instruments for H.T.S.T. operations on a masonry pier will reduce vibration, enable the instruments to work better, and extend their life.

The intention in this presentation is not to go into the myriad of details which are involved in plant construction, equipment installation, or plant operations. It is obvious from the coverage given that only highlights have been considered. The approach has been one of showing the bases for a good working environment which makes it possible to conduct a sanitary operation. They represent the passive phases of plant sanitation. Given the proper tools the remainder becomes a matter of willingness, supervision, and know-how.

## SANITATION CONTROL

On the active side of plant sanitation there are two obvious methods by which a plant operator or a control agency would measure plant performance. These are plant inspection and laboratory control whether exercised by the operator or official. In my opinion the two procedures complement each other. Each one separately has a place and a value in showing some facets of an operation but to get the picture well-rounded out it is necessary to use both means.

Frequently, defects in an operation fail to manifest themselves in an obvious way but the result of a laboratory examination nevertheless points up the existence of a problem. This should result in a highly detailed observation by the alert inspector to ascertain the cause. In a converse manner, the physical inspection may lead to a suspicion or a doubt about a particular plant practice which can frequently be resolved by sampling and laboratory reporting.

The need for this double-check type of sanitary control has become more or less established by the progressive segments of the fluid mlk industry and by milk control people. This has probably arisen through necessity and not because milk people are more scientifically minded or more progressive. The nature of the product being handled and the compelling health necessity for milk safety have undoubtedly influenced this trend. The idea has taken root in the case of other food industries and can be greatly expanded. Inspection agencies can encourage the trend by convincing the food industry of the worthwhileness of good laboratory control and a good inspection service.

# FOOD HANDLER TRAINING PROBLEMS*

W. H. HASKELL

*Klenzade Products, Inc., Beloit, Wisconsin*

DR. W. H. HASKELL is director of programs for Klenzade Products, engaging in educational activities involving milk and food sanitation. He is a graduate of the School of Veterinary Medicine at the University of Pennsylvania. He served in the Milk and Food Section of the U. S. Public Health Service 1926–1947.

AN evaluation of the merits and necessity for food handler training presents many items for scrutiny. First among these components is reasonable proof that food handler training is necessary. In support of the belief that such training is essential, the following references are quoted:—

Ravenal and Smith, in an article in the *Journal of the American Medical Association,* May 22, 1909, reported an outbreak of typhoid fever due to handling of dishes in a college boarding house by a typhoid carrier, 42 cases in less than a month. The report stated, "With all other sources excluded, dishes handled by this student were the only possible source of infection."

In December, 1918, Lynch and Cumming, in an article in the *Military Surgeon* stated, "Influenza is a hand to mouth infection. The prevention of the hand to mouth infections may be accomplished by any measure which will prevent the unclean hand from visiting the mouth and nose. Transmission by direct contacts is only subsidiary to the direct routes."

Cumming, writing in the *American Journal of Public Health,* January 1919 —Distribution of Infection by Indirect Contact, Hands and Eating Utensils— states, "In the prevention of sputum-borne epidemics, the hygiene of the hand and the hygiene of eating utensils is of paramount importance; clean hands, disinfected eating utensils, the avoidance of intermediate object conveyors handled by many persons, the frequent cleaning of such conveyors, the keeping of the hands away from the mouth and nose, and eliminating the sick from the kitchen, these are the essentials of such protection." "We have isolated 12,000,000 organisms from the ladle of a spoon used by a streptococcus carrier."

Brown, Petroff, and Pesquera in the *American Review of Tuberculosis,* December 1919, stated, "On eating utensils it was found spoons, forks, glasses, cups were contaminated with tubercle bacilli; the transference of tubercle bacilli to eating utensils, and thence if not cleaned, to a second person, has been borne out."

In *The Military Surgeon,* February 1920, appeared this statement, "Eating utensils are the most common source of distribution of sputum-borne disease among civilians."

Lyons, in *The Journal of Bacteriology,* May 1936, in reporting on the presence of *Borrelia vincenti* and other spirochetes on beverage glasses states, "Very high counts were found on the rims of supposedly clean glasses. *Borrelia vincenti* was isolated in 24% of the samples."

A more thorough search of the literature would undoubtedly reveal much more material indicating the necessity for an educational approach to food-handler training.

A second consideration should be: What is a food handler? Shall we limit the educational activities to those connected with employment in eating and drinking establishments? In my opinion, milk should definitely be included in considerations of food-handler training. The milk producer is assuredly a food handler, as well as the employees of pasteurization plants and other processing plant workers in the various branches of the dairy industry. It is believed that many of the regulation compliance failures experienced in milk sanitation have been in a large measure due to absence of educational programs designed to provide the essential "know-how" for the employees, as well as the owners and operators, of the various components of the dairy industry. In our newer concepts of sanitation, it is not advisable to exclude any group of citizens from our educational activity.

The problems involved in the training of food handlers are many and some considered important are presented here briefly. Some of the items may apply in certain areas, other considerations in different localities. Itemized, they are as follows:

### 1. Training of Instructors

There is a decided scarcity of individuals with training as sanitarians and training as instructors. From the Federal level on down we conduct seminars in sanitation for the purpose of providing instruction in the various fields of sanitary science, yet we have failed to recognize the fact that teaching also has its specific applications, and no seminars in the correct application of instruction procedures are provided the sanitarian. It may be claimed that we have health educators for the purpose of teaching but at last count there was a shortage of over 6,000 health educators, therefore the teaching burden still must be carried by the sanitarian.

### 2. Coordination of Instruction Programs

Lack of any semblance of uniformity in food handler training is decidedly detrimental to the entire national training program. From the original twelve hour instruction courses, conceived and prepared by Dodson of Texas, we now have training courses presented as complete teachings in any number of hours. Eight hours, six hours, four hours, three hours, two hours, even so short a time as one hour are used in presenting what are claimed to be complete instruction courses in food handler training.

There is a decided need for unification of our thinking on the length of our complete instruction programs. It is reasonable to a ssume that it requires certain time considerations for the adequate presentation of material covering the various ramifications of public health problems involved in the food handling business.

In my opinion no training program should be attempted unless the presentation of complete, adequate instruction is contemplated.

Another factor in which lack of coordination is noticeable includes the scarcity of suitable teaching material.

* Presented at the 36th Annual Meeting, INTERNATIONAL ASSOCIATION OF MILK & FOOD SANITARIANS, INC., Columbus, Ohio, October 20, 1949.

Much of this scarcity of material is due to failure of governing agencies at all levels to provide sufficient funds for purchase of projectors, films, slides, and other supporting material essential to program presentations. In addition, it is only human to obtain satisfaction from self-developed material and such development should be encouraged; yet frequently such material is used more for its artistic composition than for its instruction value.

There is a great need for more uniform teaching aids, fully described and outlined for use. Until such aids are adequately provided it is extremely doubtful that courses will cover much of our suburban areas or be sufficiently expanded to provide adequate instruction.

### 3. Work Load Involved

In many areas the sanitarian, believing in the value of education and hopeful of securing beneficial results, enters into the training planning activity. Immediately it becomes apparent that a tremendous work load is being added to an already crowded work day. The instruction, of necessity, must be fitted to the work periods of the various industries, and night instruction is the rule rather than the exception. Much of the tendency to provide "clipped" instruction stems from the desire to limit the work load.

It is believed that adequate instruction will replace a considerable portion of the usual inspection load and, to a certain extent, time factors in each activity will balance.

The training of several instructors for the purpose of providing substitute teachers is also of tremendous help in limiting individual work loads.

In any event, the instruction programs mean work but the accomplishments provide great satisfaction.

### 4. Understandable Instruction

Course material should be well prepared and above all presented in an interesting manner. Employees will usually respond satisfactorily to the presentations made in an appealing, attractive way, but will most assuredly react unfavorably to dull, uninteresting classes. This phase of the problem rests entirely in the hands of the instructor. Food handlers classes should be prepared and presented at a level understandable to the average 16-year-old, not at the level of higher education. Get down to the job level and forget you are in a classroom.

### 5. Meeting Places

Comfortable, well ventilated, quiet places with comfortable seating and easily darkened windows are at a premium in the United States. The comfort of those attending classes has much to do with the success of the venture. Picture projections, in half-darkened rooms, street noises, uncomfortable seating, poor ventilation, all contribute to audience discomfort. Audience discomfort increases absenteeism and without attendance instruction is of little value.

Select a comfortable meeting place and, if possible, make it permanent. If it is permanent, folks soon learn where it is located. The class room should be easily accessible and its location well advertised among the interested agencies.

### 6. Attendance

Insofar as possible, attendance at classes should be limited to about 50 persons. Most colleges and universities advocate this approximate student load. It will be found that instruction is much easier, better received and student participation greatly increased. In larger classes, registration occupies a considerable portion of the instruction time. Frequently, due to large attendance, registration is cancelled and individual attendance unknown and not credited.

Food handler classes attended by approximately 600 individuals at one session have been held in this country and in such instances about all that may be rightfully claimed is that "We had food handler training classes."

In efficient instruction, the class teaching load is important.

### 7. Sessions

Have everything ready well in advance of the hour classes are to begin. Try out projectors, have material in place and *Be Ready*. Start sessions on time and stop on time. Do not allow credit for attendance at a class if an individual is over ten minutes late at any session. Build respect for the instruction and play fair with those who give you full time attendance. If you issue attendance certificates, have them mean something. Failure to require full attendance time, and granting certificates for less than required attendance has done much to lessen respect for the training programs, and the problems are increased in proportion.

### 8. Support of Industry

Without industry support, food handler training is difficult. Industry support is not difficult to secure. Owners and operators should be called together and the entire project fully explained. Local organizations such as the Junior Chamber of Commerce, Business Leagues, and other civic bodies will usually assist. They also should be fully informed as to the purposes and content of the course. No organization willing to offer assistance should be ignored. Get the various women's organizations interested and give them something to do in the undertaking. Round out your program and plan to create and sustain the essential interest.

Without support from civic groups, the difficulties of the problem are increased. On the other hand, it is believed that much good would result if the various local organizations contributed funds to defray the expenses of maintaining food handlers classes. This is assuredly a project whereby the whole community would benefit. A permanent classroom, properly equipped, which would be the center of continuous sanitation training activities, would focus the interest of the whole community on the food handlers education.

### 9. In-Service Industry Training

There have been disagreements in many places between authorities and representatives of industry on the conducting of industry training programs. Industry representatives have been at fault in insisting that they conduct their sanitation training within the framework of their own organization, and health authorities have criticized industry because sanitation was not included to an essential extent in the industrial courses.

The right of industry to conduct its own in-service training classes should not be questioned, but industrial responsibility most certainly embraces public health and education in sanitation by trained sanitarians is definitely a part of industrial in-service training.

Employment of qualified sanitarians by industry has been of great assistance in overcoming this breach, but until such time as greater use of the services of trained sanitarians is utilized by industry, the public health training

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# WHAT THE CITY OFFICIAL DESIRES OF HIS SANITATION DEPARTMENT *

O. W. JOHNSON
*Mayor, Hastings, Nebraska*

MR. JOHNSON has been Mayor of Grand Island since April 11, 1950. He was the first Mayor elected under the City Manager form of government. Mr. Johnson has taken an active part in civic affairs for many years. He served as President of the Grand Island Rotary Club during 1936 and was elected District Governor of the Rotary in 1948. Mr. Johnson was the first President of the Grand Island Engineers Club in 1930.

"SANITATION is a way of life. It is the quality of living that is expressed by the clean home, the clean farm, the clean business and industry, the clean neighborhood, the clean community. Being a way of life, it must come from within the people; it is nourished by knowledge and grows as an obligation and an ideal in human relations."

NATIONAL SANITATION FOUNDATION

"The sanitary control of the environment is the most important foundation stone of a community-wide public health program. The simple sanitary principles for prevention of disease and promotion of community health that may be applied in any community, large or small, are quite elementary, yet they are so fundamental that they must always be the chief concern of the official health service."

W. C. SMILLIE, *Professor of Public Health and Preventative Medicine, Cornell University Medical College*

These two statements, one of definition and one of classification of the field of sanitation, are sufficient to acquaint a public official with the broad implications of sanitation.

In considering further these statements, one realizes that the successful sanitarian, to further these aims, must be first a social minded person, one who knows and senses human reactions; who can inhibit the unsatisfactory and stimulate the satisfactory responses in others, at the same time deserving and gaining the respect and liking of those with whom he comes in contact. He must understand local politics, not for the purpose of practice, but to avoid the entanglements and pitfalls; he must also possess imagination. With these characteristics and a knowledge of the basic requirements of sanitations and a thorough knowledge of state, county and municipal laws and regulations pertaining to sanitation, the sanitarian is equipped with the working tools of his profession. With these assets, we must add the fuel to impel him forward. This fuel is enthusiasm.

Having equipped our sanitarian and endowed him with enthusiasm, what should we, as municipal officials, expect of his department?

First, we should and do expect him to be on the alert for any possible dangers to the health of the people in the community from any diseases that might be transmitted by reasons of insanitary conditions. If, in his opinion, any such danger to the community is imminent, it is his responsibility to take such steps as he deems necessary to alleviate the condition. In matters of this nature he should advise his governing body of the dangers that are facing the community and counsel them on proper procedure to arrest the danger. Knowing that much of his department's activities are routine, we city officials should insist on periodic reports of the work accomplished.

Considering our sanitation department as the barrier between many diseases and our susceptible population, we should insist that he keep a close check on many accepted facilities of community life.

Let us consider the water supply to the community. The municipal water system has, no doubt, been designed, approved, and installed by skilled and responsible individuals, but regardless of this careful planning and installation, certain defects, perhaps beyond the control of ordinary supervision and operation, might develop.

It is here the city officials have a right to expect certain supervision beyond the ordinary mechanical supervision, from its sanitation department. This supervision by the sanitation department should embrace routine physical supervision of the existing system, coupled with routine sampling of the supply from certain vantage points in the system for bacteriological examination. In the event of any deviation from normal as indicated by the laboratory findings, immediate steps should be taken to determine the cause and to make recommendations to remedy the abnormal condition.

To a lesser degree, all private water supplies should be sampled for laboratory findings when any indication of contamination is evident.

Let us consider next one of the most basic items of community sanitation, that of sewage disposal. As with water supplies, most sewerage systems were intelligently designed and installed, but again when we examine the entire layout with its complex bio-chemical sewage treatment plant, we have a right to expect a sanitarian to be aware of any deviation from the normal in the operations, and to warn us before serious danger from such a source can occur.

It is perhaps fortunate that many of the most important measures in sanitation have contributed to the convenience and comfort of the individual. It is doubtful if our people would have installed water in their homes or an indoor toilet if it had not made life more pleasant. Yet many people in every community, because of one reason or another, continue to use outdoor privies and secure their water from a yard pump. It is here we expect the sanitarian to ferret out potential dangers to the community and, by education or resorting to any ethical means, to remedy these conditions.

Let us consider our milk supply, a product capable of conveying more types of illness than all other foods combined. We expect our sanitarian, by virtue of proper education of, and guidance to, the dairy industry, both on the farm and in the process-

* Presented before the Nebraska Public Health Association, Lincoln, Neb., November 21, 1950.

ing plant, to assure a safe, wholesome milk supply to our community.

It is interesting to note that in most areas employing trained sanitarians, laws have been passed to preclude the sale of raw milk and dairy products within the area. This, no doubt, has been induced by the advice of the local sanitarian.

Garbage and refuse collection and disposal—here again, as with sewage disposal, it is the community's responsibility to insure proper collection and disposal of its garbage and refuse wastes. The more modern city official realizes that supplying a dumping area near a community does not fulfill the ultimate in community sanitation. It has been demonstrated time and again that a poorly kept dumping area may supply a community with disagreeable odors, rodents, flies and other items that may affect the health of the community. The official governing body of any community should expect their sanitation department to advise as to approved collecting practices, and also the proper and most practical manner of disposing of these wastes. Realizing that in different communities conditions vary, a local sanitarian should be well enough informed to develop the proper method of collection and disposal for his particular community.

Referring again to the food industry, we expect a sanitarian to develop and promote a good food-and-drink establishment program of sanitation. Perhaps this is one of his most important and difficult assignments. We know that standing over the food handler with a club is impossible, and we can expect improvements only so far as we educate and convince the food dispensing industry that good methods of food handling are profitable and desirable to them. In this field we expect our sanitarians to supervise the industry, pointing out the dangers of improper practices in food handling and, by means of personal education, instructing the industry to store and serve food in a sanitary manner.

Rodent and insect control are still other fields of endeavor of our sanitarian, and again we expect him to keep current on new methods of controlling these vectors of disease. This is a never ending battle. A constant program of rodent control should be a part of any sanitation program. With the newer insecticides available for use today, we expect our sanitation department to be aware of their uses, and by actual use of them as well as by advising and cooperating with other agencies, help control our undesirable insect population.

We should expect our sanitarian to be aware of certain housing conditions that might affect the health of our people, and also be alert to any potential dangers to our people from such sources as might result from improper industrial hygiene practices. We should expect him, with his knowledge of water supplies, to carry this knowledge over into the fields of swimming pool and wading pool sanitation, to supervise the sanitary practices that must be observed to maintain these pools in a manner not detrimental to the health and well-being of those who patronize these places of recreation.

It is my opinion, and in my own community it has been so arranged, that the sanitarian be able to support his own activities by affixing fees in such a manner that the industry or individual receiving the benefit of a sanitarian's supervision pay such monies as are necessary to carry out the work. This, of course, may not be carried to perfection, but in the main it has worked out very well in my community.

The sanitarian—the man. I do not believe the sanitarian himself needs to qualify as to type, that is, tall, dark and handsome, or blonde, broad and beautiful; however, I am sure he must meet certain requirements very definitely.

Here are a few of the important qualifications I think he should have:

1—A thorough knowledge of the subject
2.—Average intelligence
3—Ambition
4—Well-groomed appearance
5—Honesty and sincerity
6—Thoroughness

Let us analyze some of these qualifications.

1—In order for a person to perform a job efficiently he must know his subject well. He may have other good qualifications and still not be able to succeed.

2—Average intelligence associated with other qualifications will be adequate. The higher your I.Q. the better.

3—Ambition is essential as it is the motive power to success. Ambition, to be of value, must be intelligently directed, as misguided ambition can only result in harm. I am reminded of an example of this while on a hunting trip in the sandhills of Nebraska. While resting on a knoll one of the party called attention to a series of furrows in the sand several hundred feet from where we stood, and gave his opinion that it looked like someone had plowed there years ago. One of the party who lived in the sandhill country and was familiar with a great deal of the early history of the hills volunteered the information that among the early settlers was a Negro family. The man was a hard worker, and being ambitious, actually plowed the clear sand and tried to raise corn there. This revelation amazed the group and one of the party turned to me and asked, "Johnson, how would you account for such an action?" I replied, "That, to me, is the result of ambitious ignorance."

4—Well groomed. I do not have in mind the fashion plate type with special clothes for all occasions. A man can be well groomed in a suit of coveralls. He should be free of B. O., his clothing should be clean, and he should be clean shaven.

5—Honesty and sincerity. He should be honest in his work on inspections and his reports should reflect the true conditions regardless of the individual or firm under investigation.

He should be sincere in his dealings with the parties being inspected in order to impress them with the importance of sanitation as it affects their customers, employees and the public at large.

6—Thoroughness. Unless the work of the sanitarian is thorough the public will lose confidence in the activity. There are many skeptics now who question the value of our sanitation work.

Our sanitarian, after being selected and meeting the qualifications we determine are required, must be delegated such authority as necessary in order that his office will be respected in the community.

From time to time, various civic groups determine upon a program of pest eradication or control through various means such as sprays, poisons and similar plans. No activity of this nature should be permitted until the plans have been reviewed by the sanitarian and his approval given. In fact, he should person-

ally supervise all such activity in order to safeguard the public.

Promiscuous use of sprays can result in harm rather than good. Nature attempted to maintain a balance in the insect world and we find that some species prey upon another and through such a plan prevent an excess of any one group. Too little is known of too many insecticides today, and there is real danger that through promiscuous use of these sprays much harm will result.

Your sanitarian receives many complaints and suggestions, and regardless of their nature, the individual offering same is entitled to a proper hearing and a suitable answer. The manner in which these individuals are received and the treatment accorded them will do a great deal in building confidence and cooperation in the work.

As a sanitarian you are responsible to your city officials for many important activities in the safeguarding of the health of the public.

You must remember that the average city official knows practically nothing about such matters, and unless you bring all matters needing attention before them in a complete and concise manner, and with proper emphasis on the importance of prompt action, your proposition may not receive approval. You must not be easily discouraged upon failure to arouse the interest you had hoped for, but demand, if necessary, a rehearing of your proposition in order to assure yourself that you have completely fulfilled your responsibility in the matter.

You as sanitarians are important cogs in the conduct of city affairs. If you are qualified in your job, you are entitled to the full support of the entire membership of the city governing body. If you are experiencing difficulty in securing support of such a group, you should demand a show down as you cannot afford to continue in your position under such a handicap. Your future is at stake and also the health and even the lives of the people of the community. Do not continue to be a party to such a situation.

If you are experiencing difficulty in securing full cooperation in your efforts, it is well to first take stock of yourself. In other words, "What is the matter with me? I don't seem to be securing the cooperation I should from my fellow workers in other departments."

Sometimes in our eagerness to succeed we overlook the other fellow and unconscientiously trample on him. May be we need this other fellow to run interference for us. Unless you have the support of the rest of the fellows on the team, you may get tripped up and thrown for a loss instead of scoring that touchdown. Always seek the cooperation of all the fellows before you grab the ball and start running.

My sanitarian must work closely with the police and fire departments, the city engineer, and all the other men on the team, and that is the way we get results.

We Grand Island folks are exceedingly fortunate in that we have a fine city, a fine sewage system and modern disposal plant, an abundance of fine water, and last but not least, a fine sanitarian in Mr. C. B. Kinnison.

Thank you.

## Food Handler Training Problems

(Continued from page 38)

inherent in food handling should be conducted by those familiar with public health necessities. It all sums up to the necessity for close cooperation between industry and official agencies.

### SUMMARY

Not all the problems of food handler training are presented here. An attempt has been made to include those considered most important.

Summarized, these are:

1. Conviction that food handler training is necessary.
2. Seminars should be held for the training of instructors.
3. Instruction should be coordinated.
4. Material for instruction should be made available.
5. Distribution of work load is essential.
6. Local support must be secured.
7. Suitable meeting places are essential.
8. Instruction must be interesting if attendance is to be maintained.
9. Industry and official agencies should carry out a program of cooperation.
10. Continuation Education.
    Basic food handler classes should be followed by additional meetings of about one hour each, continuing over a considerable period of time. The continuation education will prove of great value in maintaining interest and providing valuable training.

It is believed that if these suggestions are reasonably followed, we can have a food handler training program for all branches of the food industry and our citizens as well.

## Sanitizing of Cans

(Continued from page 12)

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# New Books and Other Publications

**Public Health Engineering,** by Earle P. Phelps. Published by John Wiley and Sons., Inc., New York. Vol. I, *The Air Contact,* with the collaboration of Dr. Harry D. Pratt, and *The Water Contact,* with the collaboration of Professor Clarence J. Velz. 1948. 655 pages. 137 figures. $7.50. Vol. II, *The Food Contact,* with the collaboration of Mr. Walter D. Tiedeman. 1950. 213 pages. 35 figures. $4.00.

In accordance with the subtitle, "A Textbook of the Principles of Environmental Sanitation," the authors have written a useful treatise which deals with the subjects of sanitary engineering more broadly conceived than those dealt with in the conventional curricula but comprised within current emphasis on the engineering and control aspects of environmental hygiene. In the first volume, part one deals with weather and climate, the air supply and conditioning, lighting, atmosphere pollution and noise, and insect control; part two deals with the water supply, sewage disposal, treatment of pollution, and rural sanitation. In the second volume, the subjects are: food epidemiology and control, milk production, and pasteurization, auxiliary processes and plant layout, milk plant inspection and control, shellfish inspection and control, public eating and drinking places, and the handling of refuse and control of rodents. The presentation is broadly informative and adequate for elementary textual study.

**The Chemical Formulary,** edited by H. Bennett. Volume IX. Published by The Chemical Publishing Co., Inc., Brooklyn, N. Y. 1951. 648 pages. $7.00.

This book is the eleventh volume in the set of formularies. Chapter I is the same as in previous books, given for the benefit of those who may have bought only this volume and have had no experience in chemical compounding (with which the chapter deals). The formulae in each volume are different from those in all the others, and the present volume represents the newer developments.

**Protein and Amino Acid Requirements of Mammals,** edited by Anthony A. Albanese, and written by six contributors. Published by The Academic Press, Inc., New York. 1950. 155 pages. $4.00.

H. H. Mitchell, University of Illinois, writes on the differences in amino acid requirements with species and age. Douglas V. Frost, Abbott Laboratories, Chicago, presents methods of measuring the nutritive value of protein hydrolysates and amino acid mixtures, and the rat repletion method. Robert H. Silber and Curt C. Porter at the Merck Institute report on "the least undesirable laboratory test for amino acid mixtures and protein hydrolysates," designed for intravenous feeding. Bacon F. Chow, at the Johns Hopkins School of Hygiene and Public Health, presents data "to demonstrate that the synthesis of tissue proteins depends not only on the presence of the essential amino acids in adequate amounts but also on the dietary proteins from which the supply of these building stones and possibly of some nutritional factors is drawn," and presents evidence for the existence of a "directive substance" in utilization of amino acids. Anthony A. Albanese, St. Luke's Nutritional Research Laboratory, New York, writes on "The Protein and Amino Acid Requirements of Man" and points out the desirability of accepting the amino and protein requirement values that are secured with the essentially normal diets versus those made up from synthetic diets.

**Plasma Proteins.** Vol. II, of the Symposia on Nutrition of the Robert Gould Research Foundation, Inc. Edited by John B. Youmans. Published by Charles C Thomas, Springfield, Illinois. 1950. 352 pages. $6.50.

Twenty-one specialists have discussed "the physical and chemical nature of the serum proteins, their formation and biosynthesis, their relation to the dietary proteins, to the function of the liver, to the immunochemical processes, and the nature and occurrence of hypoproteinemia and its relation to edema."

**Byproducts from Milk,** by Earle O. Whittier and Byron H. Webb. Published by the Reinhold Publishing Corporation, New York, N. Y. 1950. 317 pages. 23 figures. 40 tables. $6.00.

In this one volume there is assembled information over a wide field dealing with the utilization of the byproducts from milk. The presentation is detailed enough to interest the advanced student of food technology, the manufacturer, the executive, and the investigator who seeks information on the state of the art. About eight hundred references support the text. The technical and production aspects are not dealt with as extensively and authoritatively as those which deal with the properties of the products.

**Testing Dairy Products and Dairy Plant Sanitation,** by G. H. Wilster. 3rd edition. Published by OSC Cooperative Association, Corvallis, Oregon. Litho. 1950. 295 pages. $3.00.

This book is the outgrowth of a former publication "Manual for Milk and Cream Testers and Laboratory Technicians" published in 1947. Part I contains directions for testing dairy products, arranged according to the product. Much practical information and detailed directions, with various precautions, assist the operator to understand what he is directed to do. Looseleaf binding makes the book lie flat, thus facilitating its use in the laboratory. Part II contains sanitation standards arranged for the different dairy products. Several problems, state standards, and score cards increase its usefulness to laboratorians.

**A Dictionary of Dairying,** by J. G. Davis, with some sections especially contributed. Published by Leonard Hill, Ltd., London. 1950. 766 pages of text.

The author states that the dictionary is written for ready reference by any scientist in other fields and by any intelligent layman in the dairy industry. With most entries, the definitions are brief (but always clear), but in many others, the information is extended and detailed, as for example, 21 pages on detergency, 12 pages on bacterial classification, 50 pages on cheese, detailed cost figures for cartons. Here is a great mass of information conveniently arranged.

# Association News

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*Assistant Secretary-Treasurer,* Donald Hayes, Turner & Wescott, Inc., 1327 N. Marston St., Philadelphia

### Central Illinois Dairy Technology Society

The December meeting of the Central Illinois Dairy Technology Society was held on December 20, 1950 at the University YMCA, Champaign, Ill.

The entertainment was execptional at this Christmas Dinner Party for members and wives. Professor Bruce Foote of the School of Music, who is also with the Chicago Theatre of the Air on WGN, presented several vocal selections.

The speaker, the former Macomb, Ill., dairyman, Anton Johnson, showed color slides he had taken on a congressional committee tour with the Navy. This flight was made five months after the Japanese surrendered and included Hawaii, Kwajalein, Okinawa, Guam, Iwo Jima, Manila, Corregidor, Samar and Guadalcanal. The pictures and Mr. Johnson's comments were enjoyed by everyone.

JOHN W. HAYES,
*Corresponding Secretary.*

### January Meeting of the Central Illinois Dairy Technology Society

The January meeting of the Central Illinois Dairy Technology Society was held January 10, 1951 at the Illinois Hotel, Bloomington, with President L. P. Harder presiding.

The speaker of the evening, Mr. V. Schwarzkopf, vice-president of the Lathrop Paulson Company, talked on the subject "Getting the most out of your can washer".

Mr. Schwarzkopf's direct approach to this problem held the interest of the group during his talk and prompted a good question and answer session afterwards.

The next meeting will be held on February 14, 1951 at Bloomington, Ill.

JOHN W. HAYES,
*Corresponding Secretary.*

### Kansas Association of Milk Sanitarians

The 21st annual meeting of the Kansas Association of Milk Sanitarians was held in Convention Hall, Manhattan, Kansas, November 15 and 16, 1950. The latest group of sanitarians ever to attend an annual meeting in Kansas participated in an outstanding educational and informative program. Many aspects of the dairy industry were incorporated in this program. The dairyman and fieldman relations to the grade "A" program were interesting topics. The legal aspects of trade barriers was ably discussed by one of the outstanding lawyers of Kansas.

Industrial problems were also on the agenda and were presented by qualified representatives of commercial suppliers. Of specific interest to the milk sanitarians were subjects on codes of ethics and laboratory bacteriological analysis as it applies to the milk ordinance.

### Dubuque Dairy Technology Society

President John Stanton has been transferred to Pasadena, California; Vice-President Fred Ament is in charge of the work of the Association until the annual election in March.

In the meeting on January 11th, Mr. J. Allen Wallis addressed the dinner meeting on his trip to Europe, illustrating it with colored moving pictures. In thirty-one years of farming he had operated a retail milk route; he established a fine purebred Guernsey herd; was President of the Iowa State Dairy Association; and has been influential in dairy circles in the state.

### Food Sanitarians School at Michigan

The Eighth Annual Dairy and Food Inspectors and Sanitarians School will be held at Michigan State College on April 10–13, 1951. This is an opportunity for the busy worker in these fields to secure the latest information on many aspects of food inspection with a minimum of time and expense. Considerable effort is expended each year in bringing together national leaders on the various topics pertaining to sanitation problems. Anyone interested may obtain full details of the School and a copy of the program by writing Dr. W. L. Mallmann, Department of Bacteriology and Public Health, Michigan State College, East Lansing, Mich.

## CUSTARD FILLED BAKED PRODUCTS *

### Eclairs, Napoleons, Boston Cream Pie, Cocoanut Custard Pie, Etc.

For the safe preparation, handling and serving of custard filled baked goods, the following rules should be observed:

1. Wash hands thoroughly with soap and hot water before starting the preparation of this product. NEVER NEGLECT TO WASH HANDS CAREFULLY AFTER USING THE TOILET. Dry hands with individual towels.
2. *Employees with open cuts, burns, sores, stomach upset or who are otherwise ill should not prepare this product.*
3. Wash all utensils, such as sauce pans, crocks, wire beaters, ladles, thoroughly with soap or other detergent and hot water, rinse and place in boiling water for two minutes. Receptacles should be picked up and handled so that fingers do not come in contact with inside portion of containers or utensils.
4. Cooking of the custard filling must be *complete*. The entire mass must be subjected to a temperature of not less than 195° F. for a period of at least ten minutes, and stirred thoroughly during this heating period.
5. The product should preferably *not be transferred* to another receptacle for cooling because it is during this process of transfer that many of the cooked custard fillings become contaminated. Cool the product in the same container in which it was heated.
6. Custard filling should be chilled *rapidly*—in one hour or less to 50° F. or less and kept at that temperature until consumed.
7. A great deal of care must be exercised to prevent contamination in transferring the cooled custard filling to the napleon layers, Boston cream pies, etc. If a filling machine is used for filling eclairs or other pastry, it must be sterilized before use.
8. The eclair filler must be completely disassembled after being used and thoroughly washed. The parts during re-assembling of the filler should be carefully handled to avoid contamination.
9. *Cloth filling bags must not be used.*
10. The finished custard filled pastries must be kept under *refrigeration at all times* during storage, transportation and display at 50° F. or less until consumed.
11. The retail baker particularly should supply a notice to the consumer that custard filled baked goods must be kept under constant refrigeration in the home until consumed and preferably should not be used after twenty-four hours from the time of purchase.
12. Manufacturers of cocoanut custard pies must follow good sanitary procedure in the making of the custard mix and must limit the amount of mix made to assure short holding periods. The baking process during which the custard filling in the shell is heated should provide exposure in the oven of the custard filling to 375° F. for at least twenty minutes.

* Instructions distributed by the New York City Department of Health, Bureau of Food and Drugs, Edwin Ludewig, *Director*.

### Florida Association of Milk Sanitarians

The Seventh Annual Meeting of the Florida Association of Milk Sanitarians will be held at the University of Florida, Gainesville, on April 11–13, 1951.

H. H. WILKOWSKE
*Secretary-Treasurer*

## Bacteriophage

(Continued from page 16)

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# News Items

DAIRY TECHNOLOGY CONFERENCE, UNIVERSITY OF MARYLAND
NOVEMBER 8–9, 1950

APPROXIMATELY 220 dairy industry men attended the Sixth Annual Dairy Technology Conference at the University of Maryland on November 8th and 9th.

The members of the Dairy Department Staff who presided at the various sessions included: Dr. W. S. Arbuckle, Dr. Mark Keeney, Dr. J. C. Shaw, and Dr. J. F. Mattick.

### Wisconsin Dairy Conference

The Dairy Manufacturers' Conference will be held March 27, 28, 29, 1951.

Further information may be obtained from Professor H. C. Jackson, Department of Dairy Industry, University of Wisconsin, Madison 6, Wis.

(Continued on page 46)

## Expansion of Cream Volume

(Continued from page 26)

The fat content of the cream layers of the 52 different herd milks, varied from 22.45 percent to 28.73 percent with an average of 25.55 percent. Similar fat contents for cream layers of adulterated milks seldom were as high as the lowest values exhibited by normal cream layers. Therefore, any value lower than 22 percent fat is indicative of this form of adulteration. Such milks should then be further analyzed, as previously suggested, for fat to solids-not-fat and fat to casein ratios of their cream layers. If all these values indicate adulteration there is little question that heat-thickened protein or some similar substance has been added to the milk. It should be pointed out, however, that milk from badly infected udders, especially when flaky, causes similar expansion of cream layers when added to normal milk and for similar reasons. The mixed milk will also exhibit greater sedimentation and the cream layers lower ratios of fat to solids-not-fat and fat to casein. In such cases the leucocyte count should give a clue to the situation and the casein to albumin-globulin ratio instead of being higher, as in the case of the adulteration, will tend to be lower than normal. It is hardly likely that fluid milk as presently marketed would be so grossly contaminated with infected milk as to arouse suspicion of adulteration.

### Summary and Conclusions

Expansion of the cream layer of fluid milk by the illegal practice of adding reconstituted superheated condensed milk depends on the presence of fine protein floccules in the adulterant. The degree of expansion is increased by larger amounts and greater viscosity of the adulterant but is prevented by its homogenization. Maximum increases for a given lot of milk and a particular lot of the superheated product is obtained when the heat thickened protein to fat ratio of the mixture is between 0.20 and 0.35.

Milk containing superheated condensed milk either skimmed or whole will exhibit greater sediment on centrifuging and higher viscosity, particularly of the under layer, after creaming, than is normal. The cream layers will contain less fat than normal and the ratios between fat and solids-not-fat and fat and casein in the cream layers will be lower while the ratio between casein and albumin-globulin will be higher than in unadulterated milk.

Detection of this type of adulteration is difficult in the amounts usually employed. The most significant criteron appears to be the ratio of fat to casein in the cream layer. If this value is less than 10.0 it is indicative of adulteration. The next most significant criterion is the ratio of fat to solids-not-fat in the cream layer. If this value is less than 3.00 it suggests adulteration. Finally, the fat content of the cream layer itself is a possible indication of adulteration if the percentage is lower than 22.0. For confirmatory purposes and especially if the presence of milk from mastitis infected udders in gross amounts is indicated the ratio of casein to albumin-globulin would be useful. This should be obtained by recognized Kjeldahl methods. Data substantiating these values are presented.

A method for separation of the cream layer employing quart bottles of milk is described.

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## News Items

(Continued from page 45)

### Washington Institute of Dairying

The Twentieth Annual Institute of Dairying will be held at Pullman, Wash., March 12–17, 1951. Special sessions for producers and fieldmen, for sanitarians, milk processors, and manufacturers of ice cream, butter, cheese, and concentrated milk products. Nationally known guest speakers. Dairy Products Judging and Scoring Contests open to the world. Excellent prizes and diplomas. For further information write Professor H. A. Bendixen, Department of Dairy Husbandry, State College of Washington, Pullman, Wash.

### Illinois Dairy Technology Conferences 1950–1951

For those interested in the field of Dairy Technology, a series of one-day conferences have been arranged. The meetings will be held in the Union Building on the Campus of the University of Illinois at Urbana. The subject matter to be covered in future conferences is as follows:

ICE CREAM MANUFACTURE — APRIL 3–4

Demonstrations of ice cream flavors and novelties. Stabilization of ice cream using Gelatin, CMC, Sodium alginate and emulsifiers. High temperature short time pasteurization of ice cream mixes; diabetic ice cream; mixes for soft ice cream; low fat frozen desserts; testing ice cream for fat.

### Massachusetts Milk Inspectors' Association

The annual meeting of the Association was held in Worcester, Mass., January 9–10. The following papers were presented:

Organizing the Milk Industry to Meet the Needs of the Massachusetts Civilian Defense Program, by Richard Aplin, Administrator, Federal Milk Market.

Public Health and Civilian Defense, by Dr. Autino Fiore, Health Commissioner, City of Cambridge.

Radioactivity and Its Detection, by James Laughrey, U. S. Food and Drug Administration, Boston.

Open Discussion Concerning the Emergency, conducted by President Percy Hill.

**ELECTION RETURNS!**

Complete returns from the recent voting show that members overwhelmingly approved the constitutional change, 223 to 17.

# Industrial Notes

### New Safeguard Water Heater, Wash Tank Aid Dairymen

The Safegard portable electric water heater introduced by the Safegard Division, Grand Sheet Metal Products Company, 1501 S. Laflin Street, Chicago, Ill., claims a good hot water supply and trouble-free operation for dairymen. The heater is equipped with a wrap-around heating element which does not touch the water making it corrosion-proof. It comes in 15 and 20 gallon capacities. The new Safegard stainless steel wash tanks, accommodate a ten gallon milk can and come in either double or single units. The single is shown above.

*Mail us your inquiry concerning any of the following notes on industrial products and literature. We shall be glad to forward them immediately to the manufacturer.*

**All-American mitt.** Heavy-duty mitt, used wet or dry for general washing, dusting, polishing; material withstands hard usage and repeated laundering. American Standard Mfg. Co.

**Han-D-Wipe.** Plastic scraper for removing excess oil and grease from palm and fingers in one operation, can be attached to machine, bench or wall. Reliable Machine Works.

**Cetox.** Hydraoxated carnauba wax, all-weather slip-proofed floor dressing, dries rapidly to clear coat and withstands water-washings. Chemical Service of Baltimore.

**Pneumatic sewage ejector system.** Collecting tank has 1-in. thick walls, tested to 200 lb./sq. in.; lead-covered float of spun copper; large openings for both inlet and outlet; tables of compressor capacities necessary and piping diagrams. Blackburn-Smith Mfg. Co., Inc.

NEW GLASS HOLDER DEMONSTRATED—A wire basket that permits complete immersion of glasses in washing and sanitizing tanks while keeping the hands dry has been invented by Willis E. Ricker of Welland, Ontario.

# Roccal® BRAND SANITIZING AGENT

## Measures up in every way as the quaternary of choice

**In the Dairy Industry**, more than any other industry, the importance of using only the best in sanitizing methods cannot be over-emphasized.

In Roccal, the *original* quaternary ammonium germicide, the dairy industry is offered a product that is laboratory controlled and tested. The uniform quality of Roccal means uniformly good results in doing a proper sanitizing job.

Roccal is a powerful germicide. In recommended dilutions, it is non-poisonous, non-irritating to the skin, virtually odorless and tasteless.

In the dairy, Roccal can be used for every sanitizing job. For tank trucks, weigh tanks, pasteurizers, separators, bottle filling and capping machines, to keep walls and floors sanitary.

Try Roccal for just one week and watch your bacteria counts go down . . . down . . . down!

Write us for new booklet describing Roccal's uses in the dairy plant and on the producing farm.

***In recommended dilutions Roccal is:***

- ☑ POTENT
- ☑ NON-POISONOUS
- ☑ TASTELESS
- ☑ ODORLESS
- ☑ STAINLESS
- ☑ NON-IRRITATING
- ☑ NON-CORROSIVE
- ☑ STABLE

**USES IN DAIRY INDUSTRY**

*To Sanitize:*

- MILKING MACHINES
- MILK CANS
- TEAT CUPS
- WEIGH TANKS
- COOLING TANKS
- PASTEURIZERS
- TANK TRUCKS
- SEPARATORS
- BOTTLE FILLING MACHINES and AS HAND and TEAT WASH

**Insist on Genuine Roccal® BRAND SANITIZING AGENT**

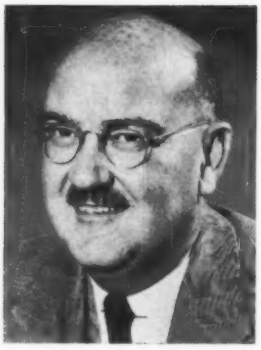
Sterwin Chemicals Inc.
SUBSIDIARY OF STERLING DRUG INC.

*Distributor of the products formerly sold by Special Markets-Industrial Division of Winthrop-Stearns Inc., and Vanillin Division of General Drug Company.*

1450 Broadway, New York 18, N. Y.

FORTIFY ALL YOUR MILK WITH **DELTAXIN®** THE PUREST KNOWN FORM OF VITAMIN $D_2$

**Distributed in the Dairy Field by Cherry-Burrell Corp. and other leading dairy supply houses.**



C. B. SHOGREN, Vice-president, Klenzade Products, Inc.

### Klenzade Fifteenth Annual Educational Seminar

On Thursday through Saturday, April 5–7, 1951, the Klenzade Products Company will hold their 15th Annual Seminar at the Pocono Manor Inn, Pocono Manor, Pennsylvania. The program will be as follows:

Thursday, April 5th

9:40 A Unified Sanitation Program Part I: Our Objective, C. B. Shogren
Part II: Our Program, W. H. Haskell
10:30 The Place of Chemistry in Sanitation, W. J. Dixon
11:00 The Function of Alternate Cleaning, P. A. Proctor
11:30 The Application of Chemical Germicides, C. K. Johns

Friday, April 6th

9:00 A Single Standard for Milk and Milk Products, I. A. Gould
9:30 Important Advances in Milk Production Methods, G. H. Hopson
10:15 Newer Developments in Plant Cleaning Aids, J. R. Perry
10:45 Quality Control in the Ice Cream Plant, J. H. Erb
11:15 Quality Control in the Milk Plant, F. J. Doan

Saturday, April 7th

9:00 The U. S. Public Health Service Food Sanitation Program, J. D. Faulkner
9:30 A United Approach to Fountain Sanitation, C. J. Palmer
10:15 Advancements in Mechanical Dishwashing, A. H. Messler
10:45 New Concepts in Canning Plant Sanitation, N. H. Sanborn
11:15 Sanitation: A Basis for Efficient Food Plant Operation, J. L. Barron
11:45 Sanitation—Present and Future, W. H. Haskell

There will be panels on Sanitation Chemistry, Bacteriology, Dairy Farm Sanitation, Dairy Plant Sanitation, and Food Service Production Sanitation given each afternoon and repeated five times. There will be educational pictures each evening and a banquet on Friday evening.

**Electric motor starters.** 2300 to 5000 v., built for full voltage or reduced voltage, reversing or nonreversing, with plugging, dynamic braking, and multispeed features; these have contractors, protective devices, meters and relays, assembled in steel cabinets. Allis-Chalmers.

**Spray pump.** Air-operated, high volume pump with device to prevent spurting, for spraying surfaces with corrosion preventatives, calking compounds, adhesives, etc., even gummy mastics and non-self-leveling substances. Gray Co., Inc., Industrial Div.


MINERALIGHT
*Ultra-Violet Light*
FOR DETECTING MILKSTONE, FATS AND OTHER SOILS

***For Sanitarians, Field Men and Inspectors***

Mineralight is a compact portable long wave ultra-violet light which causes fluorescence in milkstone, fats, and other soils not readily seen by the eye. Used like a flashlight. Operates 110 V-AC or batteries. Adapter available for 110 V-DC. Carrying case optional, but necessary for battery operation. Moderate cost. Valuable aid to any size plant. Indispensable in improving sanitary standards. Write for literature.

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**EVERY MILK SANITARIAN SHOULD HAVE, FOR READY REFERENCE, A COMPLETE SET OF 3-A SANITARY STANDARDS FOR MILK-HANDLING EQUIPMENT PUBLISHED TO DATE.**

Reprints of published sanitary standards may be obtained from George A. West, Secretary-Treasurer of the Association, 44 Marshall Street, Rochester 2, N. Y.

At $1.25 per set of eleven